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Materials Engineering in Product Design & Manufacture

Materials & Methods

February 1954

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FEATURE ARTICLES

MATERIALS & METHODS MANUAL NO. 102

ENGINEERING FILE FACTS

DEPARTMENTS

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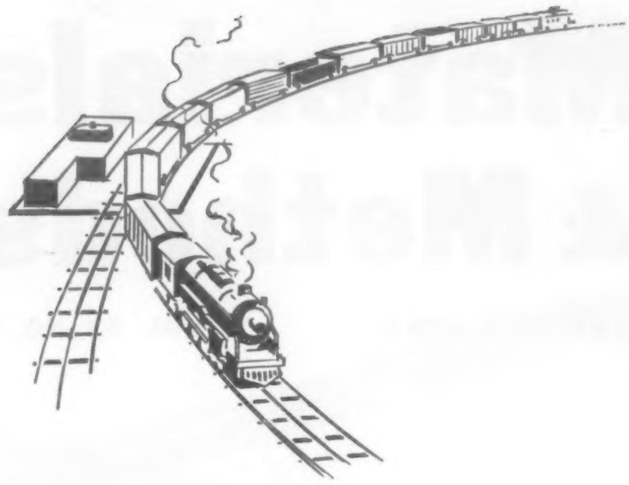

Lionel is on the right track

Here is an Inconel pusher tray designed by ALLOY ENGINEERING COMPANY, Berea, Ohio. The Inconel basket being loaded on the tray (above) contains parts that will be sintered at 2050° F. Each tray is "double-stacked" to utilize furnace capacity.

Pusher trays, like those used at The Lionel Corporation in Irvington, New Jersey, take a two-way beating.

Here's what a daily grind those tough, oxidation and corrosion-resisting Inconel® trays go through.

First, they are loaded with two Inconel baskets holding twenty pounds of parts each. Then they start on the journey through the 1650° to 2050° F. furnace, pushing the tray ahead. The furnace atmosphere is exothermic or endothermic reducing gas. They spend 35 or 40 minutes in both the pre-heat zone and the hot zone and then two hours in the cooling zone.

And they go through this cycle as many as five times a day for as long as 15 months without failure. All they require is an occasional maintenance of welds and straightening. These trays are designed and fabricated by Alloy Engineering Co., Berea, Ohio.

Inconel may be the answer to your problem, too. You'll find that it has extra strength at high temperatures... that it is ductile and readily fabricated. Welded joints in Inconel are as strong and heat resistant as the alloy itself.

Write to Inco for your copy of an interesting booklet for the heat treating industry. Ask for "Keep Operating Costs Down . . . When Temperatures Go Up."

THE INTERNATIONAL NICKEL CO., INC.
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INCO TRADE MARK

Inco Nickel Alloys

Inconel ...*for long life at high temperatures*

For more information, turn to Reader Service Card, Circle No. 380

The Materials Outlook

LAMINATED HARDBOARDS

A British-developed laminated hardboard is now being marketed in this country. Unlike most compressed wood materials it is not resin-impregnated. Resulting high machinability, combined with high compressive strength, is claimed to make it an economical tooling material for sheet metal work. It is also used in aircraft propellers and helicopter blades.

ALUMINUM IN PRESSURE VESSELS

Feasibility of aluminum for pressure vessel construction, discussed recently in this column, has been boosted still further with Code approval of GR40A (A54S), a new nonheat-treatable alloy. This magnesium-chromium alloy permits a welded design stress 18% higher than GR20A (52S), the strongest aluminum alloy listed in the 1952 Code, and 120% higher than M1A (3S), the aluminum alloy most widely used in pressure vessel applications heretofore. Ability to use thinner walls should make engineers take a second look at the good corrosion resistance of aluminum in designing chemical plant equipment (more details in a forthcoming issue).

MORE ALUMINUM ALLOYS

Sketchy reports point to some interesting aluminum alloy development work on the Coast. Several months ago an extrusion alloy claimed to have an ultimate tensile strength of 100,000 psi was announced, although no further details have been forthcoming as yet. Latest report concerns a heat-treatable alloy, designated 66S, that is said to bridge the gap between 61S and the stronger, more costly 24S and 14S types. Tensile strength of 50,000 psi, yield strength of 45,000 and elongation of 8% are claimed.

STILL MORE POLYETHYLENE

Latest report on the number of polyethylene producers, present and future, goes like this: two now producing; four more producing within two years; two more getting ready to jump into the competition. Total: eight.

METAL THAT REMEMBERS

A Columbia University professor is trying to find some practical use for an interesting new alloy he doesn't quite know what to do with. A bar of this metal, which is an alloy of gold and cadmium, can be bent easily when cold. Upon being heated to about 150 F, however, it quickly resumes its original shape.

(Continued on page 4)

The Materials Outlook *(continued)*

METAL VS. PLASTICS

At least one producer of metal stampings is hedging against any possible loss of business to reinforced plastics. Convinced that glass-polyester applications are on the upswing, this company has established its own well-equipped plastics molding department and is already filling several orders.

TITANIUM CATHODES

The possibilities of titanium and zirconium as cathodes in the electrodeposition and electroforming processes are being studied by the British. Both metals appear to be electrochemically neutral in all aqueous plating baths and they are resistant to attack by the solutions. Their surfaces have no effect on the grain size or grain orientation of the deposited metals. In addition, electrodeposits can be easily stripped and the cathodes reused without special surface preparation other than a brief cleaning etch and exposure to air for passivation.

EXTRUDING DIFFICULT FORMS

Aluminum wheels and fans up to 4.5-in. dia and 1½ lb are being hot extruded to finished sizes at the rate of 100 per hr on a specially designed 1100 ton press. The aircraft turbine parts were previously made by hand duplicating which required 4 hr per fan. Higher strength, as well as considerable cost reduction, resulted from the change.

ALKYD-STYRENE PRESCRIPTIONS

Pretty soon it should be much easier to formulate alkyd finishes suitable for various specific applications. In a research project now underway, copolymers with systematically varied proportions of alkyd and styrene resins have been tested for hardness, solubility, tensile strength, resiliency and chemical resistance. The result is a "prescription" chart that may increase the usefulness of these coatings.

GLASS-ALUMINUM COMPOSITE

A strong, attractive composite of glass and aluminum honeycomb is now commercially available. The material is a sandwich of ordinary window glass faces bonded to the honeycomb core. Degree of translucency can be controlled in manufacture, and color tints can be provided by means of dyes added in the bonding process.

POLYESTER-GLASS IN AUTOS

Typical of the knotty materials problems raised by the use of polyester-glass in auto bodies is that of reverse impact, such as might occur when a stone is deflected up from the road under the fender. It took a new resin formulation to prevent such normal impact from causing a dent that would be visible in the outer finish of the plastic fender. . . . There seems to be a feeling in the auto industry that the price of glass-polyester reinforced plastics will drop from $1.00 to about 60¢ a pound in the next five years, and still less in years to come.

Another new development using

B. F. Goodrich Chemical ***raw materials***

B. F. Goodrich Chemical Co. supplies only the Geon polyvinyl chloride compound for the drain rail.

KING-SIZE MOLDED VINYL "RUN-OFF" improves freezer unit efficiency

PICTURED here is another new use for Geon polyvinyl resin—one that shows how readily adaptable Geon is to unusual requirements.

It's a flexible drain rail for conveying defrosted water from a freezer unit—one of the largest, injected molded vinyl parts ever made. It not only provides a trouble-free means of carrying off defrosted water to the drain pan, but has many extra advantages.

Because it is made of Geon polyvinyl plastic, it is kept clean easily with a wipe of a damp cloth; household cleaning detergents, solvents, oil and grease do not affect it. Also because of Geon, it withstands wide temperature changes without becoming hard and brittle—imparts no odors to stored food.

The unusually large size of this drain rail illustrates the many possibilities for injection molding with Geon vinyl compounds. It measures 4½ feet from tip to tip and nearly 2 inches in width, weighs 21½ ounces. Installation in the refrigerator is a simple operation.

You may get an idea from this of how a Geon material can help you improve or develop more saleable products. Geon materials can make products flexible *or* rigid, transparent or opaque. They have helped solve many problems—and build sales for such products as tablecloths, curtains, flooring, wire insulation, gaskets and many more products for home and industry. We'll help you select the Geon material best suited to your needs. For information, please write Department GN2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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Geon *Polyvinyl Materials*

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMO

For more information, turn to Reader Service Card, Circle No. 314

Basic Materials Conference Advisory Committee for 1954.

Materials Conference Program Mapped

Advisory Committee Appointed

In Chicago on May 17-20 the second Basic Materials Conference will bring together at one place and time a vast amount of information on the development, interrelationships and proper uses of engineering materials available to modern industry. Unique in that it will cover the entire spectrum of materials used in product design and manufacture, rather than concentrate on an intense analysis of a single family of materials, the conference will offer numerous opportunities for manufacturers and engineers to weigh the relative advantages of one material over another.

The "horizontal" organization of the conference will permit the broadest possible basis for functional and comparative analysis. The sessions will not attempt to explore all the properties of a particular material, as it is felt that this is covered adequately in the many meetings of specialized, vertical fields. However, the vast influx of new materials and the rapid development of new processes and uses centered on both new nd traditional materials calls for a iodic "round up" at which designers, engineers, and executives can work out their material engineering problems with the help of scientists, researchers and design engineers thoroughly experienced in their respective fields. The Materials Conference provides the setting for this round up.

Saul Poliak, president of Clapp and Poliak, Inc., New York, producers of the conference, pointed out that the purpose of the conference is to "acquaint executives with the relative advantage of using a particular material instead of another. . . . A manufacturer who is undecided about the use of plastics, or wood, or steel, or light metal for next year's model should find his answer either in the conference sessions or on the exhibit floor."

For the second year in a row, T. C. Du Mond, editor of MATERIALS & METHODS, will be general chairman of the Materials Conference. Serving with him, in an advisory capacity, will be a committee of 19 scientists, researchers and design engineers drawn from top levels of the country's industrial and governmental organizations. The committee has organized a program that will cover the following general outline:

Monday, May 17. The opening sessions will include a general survey of the status of materials in today's economy, with emphasis on the part new materials developments are playing in the constant search for better, more economical production of products. There will also be a review of the materials that have been developed in connection with rocket and guided missile research and an analysis of how these new, high temperature, corrosion resistant and high strength materials can benefit industry. Monday afternoon will be devoted to methods for combatting erosion and corrosion through materials selection and processing.

The second day of the conference will be devoted to panel discussions. The morning session will survey the new metal forming processes. The discussion will center on how, where, and when to use such techniques as shell molding, powder metallurgy, investment casting, impacting and extrusion.

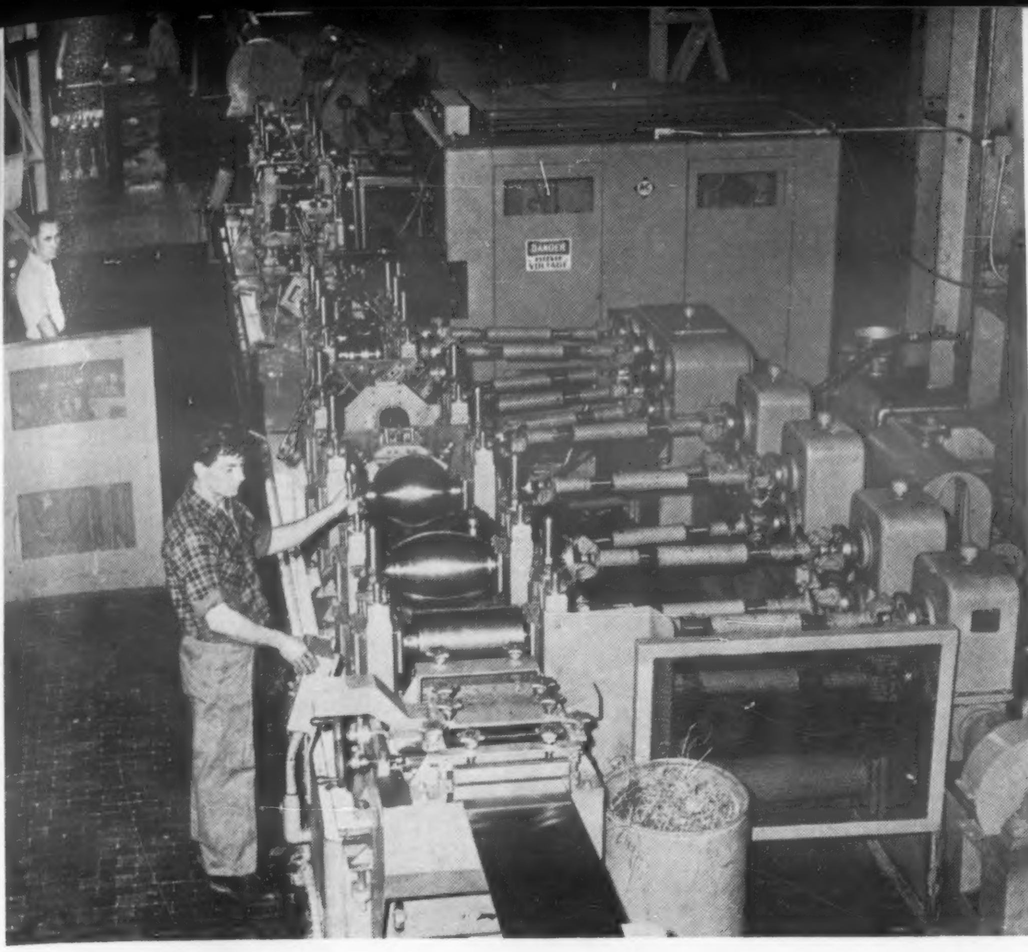
Tuesday's afternoon panel will turn the spotlight on the growing field of nonmetallic materials. In this area, where material selection must be most rigorous in order to ensure product performance under many conditions of end use, the panel will discuss plastics, carbon and graphite, glass and ceramics, and rubber.

On Wednesday, May 19, the last day of the conference, the morning will be devoted to a discussion of the growing field of industrial adhesives and how they are used in bonding metals and plastics. The afternoon session, by way of review and summation, will deal with setting up and operating a materials department in a manufacturing company.

The Advisory Committee serving with Chairman Du Mond includes:

Fred Boshoven, Materials and Components Engineering, Lear, Inc.; William Browne, Manager, Mechanical Engineering Dept., Battelle Memorial Institute; John M. Chamberlain, Vitro Corp. of America; F. M. Clark, General Engineering Laboratory, General Electric Co.; Charles C. Conley, Research and Engineering Div., Houdaille-Hershey Corp.; O. J. Feorene, Industrial Engineering Div.,

(Continued on page 218)



Thin aluminum strip, continuously fed into forming mill, is rolled into tubing, welded by induction. *Kaiser Aluminum*

Induction Welding Speeds Nonferrous Tube Output

Mill Handles Thin Gages

Production of thinner walled, welded-seam nonferrous tubing has jumped as a result of the successful development and installation of several new induction-welding, tube-forming mills.

The use of induction welding permits high-speed production of cold-formed thin gage tubing from almost the entire range of aluminum alloys available in coiled sheet form, as well as from a wide range of brasses, copper and nickel alloys, austenitic and ferritic stainless, and lighter gages of carbon steel.

Operating at production speeds up to 120 ft per min—comparable to the rate for resistance welded steel tubing—the mills roll out ¾ to 8-in. dia thin gage tubing in any desired length.

Kaiser Aluminum has installed two of the Yoder-developed mills in its Trentwood Works and is turning out 3 and 4-in. irrigation tubes for portable irrigation systems, a product now in high demand.

Kaiser reports that the welded tubing possesses superior properties with respect to strength, smoothness, uniformity of wall thickness and appearance. Production rates are higher than by extrusion, which has been used hitherto in the manufacture of most aluminum tubing. Kaiser expects to find markets for much of its production among the widespread applications of tubing in furniture, appliances, chemical plants, conduit, and other uses.

In the past, production of nonferrous tubing has been largely limited to hot processes because the abrupt melting point of most nonferrous metals precluded high welding speeds. Use of the induction process has boosted speed from 10 to 30 times that of conventional methods. Induction welding also permits the fabrication of much thinner walled tube. In extruded aluminum alloy tubing, the practical minimum wall thickness has been about 0.050 in. Cold formed, induction welded tubing can be produced in gages as thin as 0.025 in. with a thickness-diameter ratio as low as 1%.

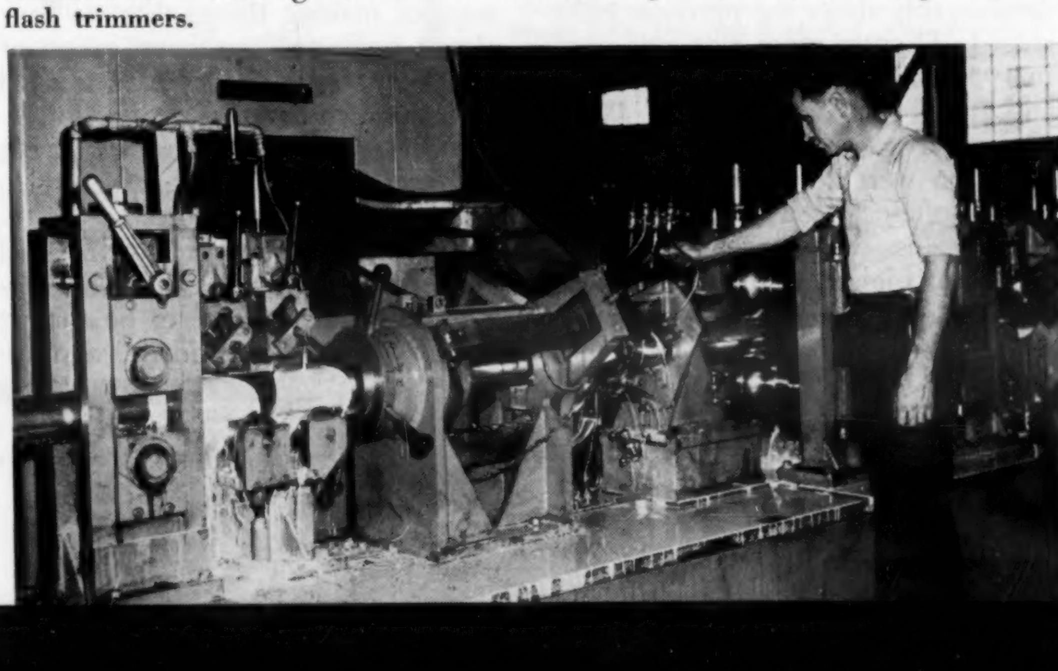
Previously, resistance welded steel tubing has been the only thin gage tubing successfully cold formed in volume at high speed. Steel tubing is commercially cold formed and welded in gages as low as 0.020 in., to a low limit of about 2% in thickness-diameter ratio.

The integrated rolling mill-induction welding set-up for nonferrous pipe was a result of previous Yoder experience in developing an induction welding mill for steel pipe and tubes which was designed to run at speeds from 150 to 250 ft per min. Initially, difficulties were encountered due to the buckling of the edges of the light gage sheet in the initial cold passes. In the final configuration of the mill, the strip is passed through nine sets of forming rolls, each of which assists in forming the strip into tubular shape. The formed, but still unjoined, tube is then passed through a high frequency induction coil.

Welding temperatures are confined to a very narrow point of convergence slightly beyond the induction coil where the edges of the tube are pressed together by a pair of joining rolls. The heat occurs in a highly limited area due to the fact that the current, induced around the surface of the tube in the region of the inductor, flows out along the converging edges of the tube and, due to both skin and proximity effect, is confined to a very shallow layer on the surface of the two abutting edges. Welds in tubes of different grades of aluminum, nickel and other metals show a uni-

(Continued on page 220)

Induction welding section of tube forming mill includes sizing rolls and flash trimmers.



News Digest

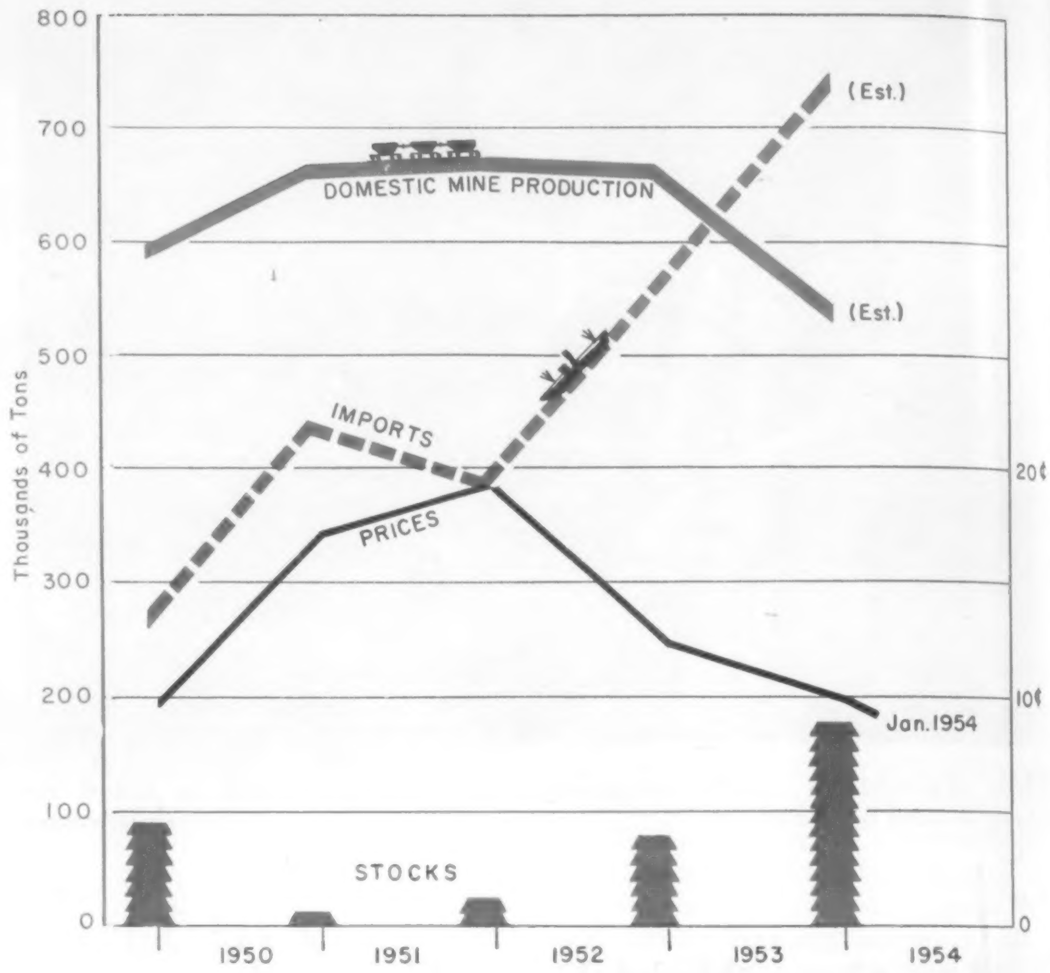
Zinc Supply Rises As Prices Decline

Zinc consumption is close to record levels, yet domestic mine production and prices are skidding. Stocks of slab zinc, now over 180,000 tons, are pushing up toward the all-time record of 260,000 tons accumulated in 1945. The E. St. Louis prime western zinc price has nosedived to the lowest level since it sold for 9.32¢ in October 1949. With present stocks on hand almost double those of 1949, a price increase is more than unlikely.

The graph at right presents a simplified picture of the general zinc supply, source and price situation. The rapid rise of imports, despite a steady price decline, has more than made up for the slowdown in production by domestic mines. Indeed, imports of slab and contained zinc in ore during 1953 exceeded domestic mine production by more than 250,000 tons. In 1952, on the other hand, domestic production exceeded imports by 100,000 tons. The reversal of the position of imports and domestic production volume may be expected to play a heavy role in the fight being waged by domestic producers for higher tariff protection.

Slab zinc production in 1953 by U. S. smelters totalled 970,935 tons, approximately 1% more than in 1952 and almost equalling the record of 1943. If slab zinc imports, nearly double those of 1952, are added to the domestic smelter production, total U. S. slab zinc shipments in 1953 amount to an estimated 1,110,000 tons.

Estimates of zinc consumption for 1953 put the total near a record 1,000,000 tons, an all time high considerably above the previous 1950 record. Slightly more zinc was used in 1953 for galvanizing than in 1952 and 1951, but less than in 1950. The chief gains in 1953 zinc consumption were recorded in the production of zinc based alloys and brass. Rolled zinc consumption was also somewhat higher, bringing the combined zinc consumption total well above previous years.



Zinc Sources, Stocks and Prices

What They Said . . . . . .

COPPER "Forecasts which predict another copper shortage in the next seven or eight years do not reflect the true picture. There will be more than an adequate supply of copper into the indefinite future — more than enough to take care of all the major applications in which copper is the preferred metal for both technical and economic reasons."—*J. M. Kennedy, Chairman of the Board, Revere Copper and Brass, Inc.*

CONTROL DISCOVERY "We in science and engineering have been so busy creating new things and new ways of making things that we have almost neglected the investigation of the creative process. We have learned some ways to organize groups to create new devices and materials; but much of the process is still left to chance. Bit by bit we are piecing together the picture of creative method and how creativeness can be deliberate and does not have to be subject to the whims of coincidence and apparent sponteneity. The advanced techniques of industrial research are definite manifestations of a preliminary understanding of the creative process." — *Maurice Nelles, Borg Warner Central Research Laboratory.*

PROGRESS "I think also that stability in the business cycle and industrial progress are completely incompatible. Stability by definition means leveling out, or to use a less pleasant word, stagnation, and I doubt that there is any thoughtful businessman who would trade progress for stability, either for himself or for the American economy. We must not accept a definition of security that merely preserves the status quo, for that will lead to stagnation and something like the dark ages of medieval history—that, you will recall, was a depression that lasted more than 800 years."—*Crawford H. Greenewalt, President, E. I. du Pont de Nemours & Co., Inc.*

(More News on page 10)

Materials BRIEFS

Nonconductor Plastic bodied cars need twice the wiring of conventional cars since the bodies cannot be used for a ground circuit. It is also necessary to shield the motor if radio interference is to be avoided in absence of the natural shield of the metal body.

Delay Lines The Bureau of Standards reports that an investigation of metal delay lines turned up some promising isoelastic alloys that yield thermally stable delay lines for use in computers and ordnance equipment. The alloys may replace mercury and quartz delay lines in some applications at considerable cost savings.

Enameled Exteriors One of the largest and oldest porcelain enameling firms has tooled up to produce porcelain enameled aluminum for the building industry. Although more expensive than porcelainized steel, builders like its light weight, easy handling, and corrosion resistance.

Nickel Deliveries have begun on the recently signed government contract with Inco calling for 120,000,000 lb of the metal over a five year period. From now until 1958 a steady 2 million pounds per month will be shipped to the U. S. from Inco's smelters.

Cold Forming A Dutch company freezes water in tubes to be bent. The ice is claimed to have several advantages over conventional fillers such as low melting alloys and resins. The tubing is left cleaner, and smooth bends are aided by deformation of the ice which occurs when bending pressure lowers its freezing point.

Titanium Nut A self locking titanium nut for aircraft and other applications where light weight is essential has been developed. The nuts weigh approximately half as much as steel, yet meet tensile strength requirements of steel nuts of the same thread.

Thermal Shock Inherently low film heat-transfer coefficients associated with the use of liquid metals in heat exchangers greatly increase the thermal stresses in equipment for nuclear reactor-power plants. The most serious problem in resisting the effect of thermal shock is to eliminate the microfissures in the weldments at piping joints.

For more information, Circle No. 316

Men of Materials . . .

their views on development and utilization of engineering materials in industry

JOSEPH B. BONANNO

Joseph B. Bonanno, as chief engineer and treasurer of the Lionel Corporation, plays a major role in the design and engineering of virtually every production part turned out by his company. While he is first of all an engineer and can seldom be found behind his desk, his executive position places him in a spot where he can observe in detail—and carry responsibility for—the economic success of his production and design decisions.

Mr. Bonanno points with pride to the fact his company produces all its own parts and assemblies. His first hand, objective experience with the hundreds of materials that can go into electric motors, housings, small parts and forms is coupled with an outstanding ability to apply new ideas to production techniques. Over 55 patents have been issued to him in connection with his work at Lionel.

He is dedicated to engineering progress and takes an active part in a broad range of engineering activities. At present he is a Senior member of the Institute of Radio Engineers, is active in the ASME, is President of Newark Chapter of the Society of Plastic Engineers and is contributing to an ASM handbook on powder metallurgy.

His basic tenet—to produce better products at lower cost—is summed up by his belief that "the constant struggle to make more and better things available to an ever greater number of people is a fundamental goal of society in general and the engineering profession in particular."

Mr. Bonanno has made major contributions to the powder metallurgy and plastics fields. He is enthusiastic about the future of both, and has this to say to designers and materials engineers:

Seldom has there been a time when designers—particularly designers of consumer goods—were faced with a greater pressure to reduce costs. The time has gone when increasing cost of labor and materials can be passed on to a public willing to pay premium prices for scarce merchandise. A buyers' market has developed and sales departments are insistent on maintaining or reducing prices even in the face of rising material and labor costs. A designer who wishes to produce a competitive product must scrutinize each component more closely than ever before to determine the most advantageous and economical fabrication method.

Such developments as magnetic non-conductors, the extrusion of steel and large aluminum sections, titanium and other new metals and alloys, new plastics and metal powders offer the designer a constantly growing opportunity. It is the designer's obligation to know and use these new materials and techniques to better his products.

In production, labor costs are rising, and generally speaking, the more labor required, the more the variation between individual parts or products must be taken into consideration. Both costs and the need for uniformity indicate a trend toward mechanization. But in utilizing automatic production techniques, the designer must keep processes flexible—ever bearing in mind that a single purpose machine can become a Frankenstein in case of premature obsolescence.

The field of powder metallurgy offers many examples of the solution of the problems involved in reducing costs, avoiding materials shortages, and mechanizing production. Where powder metallurgy is adaptable, costs often can't even be compared to other processes. In volume production of small structural parts, cost reductions as much as ten to one or more are common. In our experience with compacted and sintered metal parts, we have found the process to be stable, to require a minimum of inspection and surveillance, and to be very economical from the standpoint of minimizing handling and transportation costs. While powder metallurgy is not, of course, a panacea for all designers' troubles, it is peculiarly useful for large quantity production of many small parts.

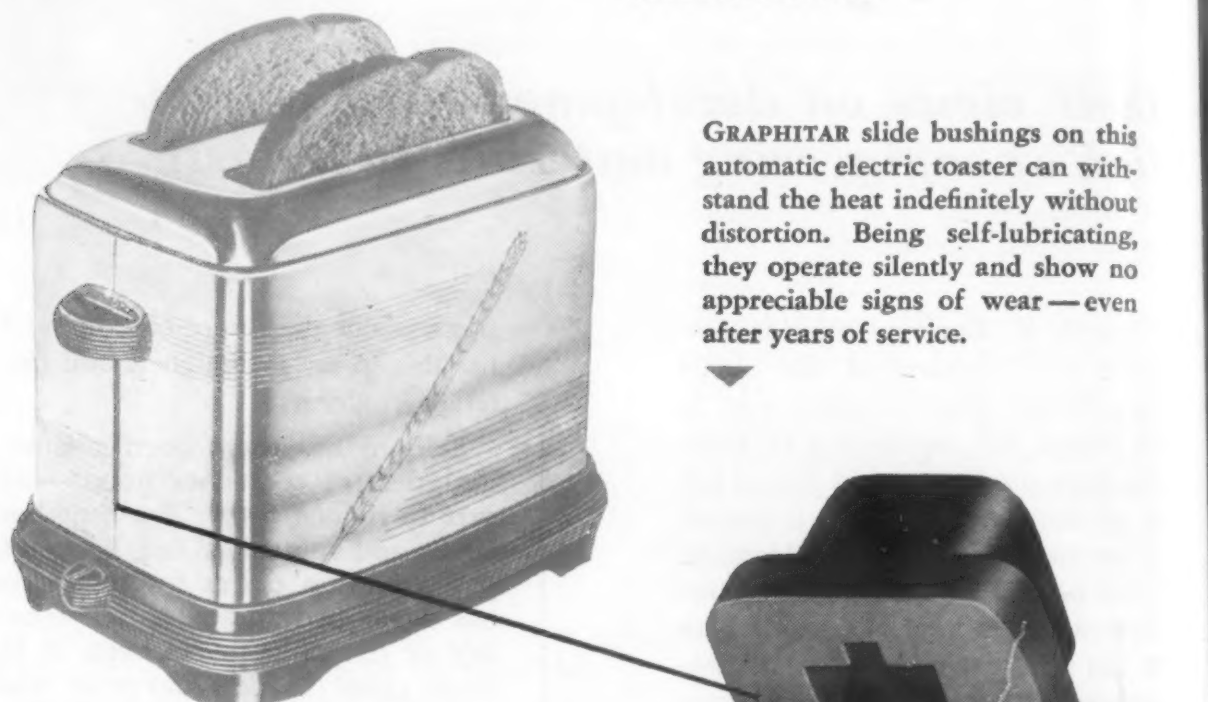
Today's designer must constantly adapt the rapidly increasing number of materials and processes to his production problems—always bearing in mind the overall costs. If a new material cost is much higher, and seems out of balance, it may still be worth investigating if the possibility exists that it will cut other costs enough to warrant its use.

In general, if a designer is alert to new developments and can employ them properly, he is constantly placing himself in a position to make a better product at a lower cost.

FROM TOASTERS TO TORQUE CONVERTERS

GRAPHITAR® PARTS

(CARBON-GRAPHITE)



GRAPHITAR slide bushings on this automatic electric toaster can withstand the heat indefinitely without distortion. Being self-lubricating, they operate silently and show no appreciable signs of wear — even after years of service.

GRAPHITAR — a versatile engineering material produced from carbon-graphite powders, compacted under extreme pressures and fused at temperatures up to 4500° F.

- can be formed in relatively complicated shapes and ground to tolerances as close as .0005″ for seals, bearings, valves, piston liners and many other parts
- lighter than magnesium, harder than most steels and mechanically strong and durable, making it ideal for use where weight is a factor
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- possesses exceptionally good wearing qualities and will outlast practically all other materials — even without lubrication
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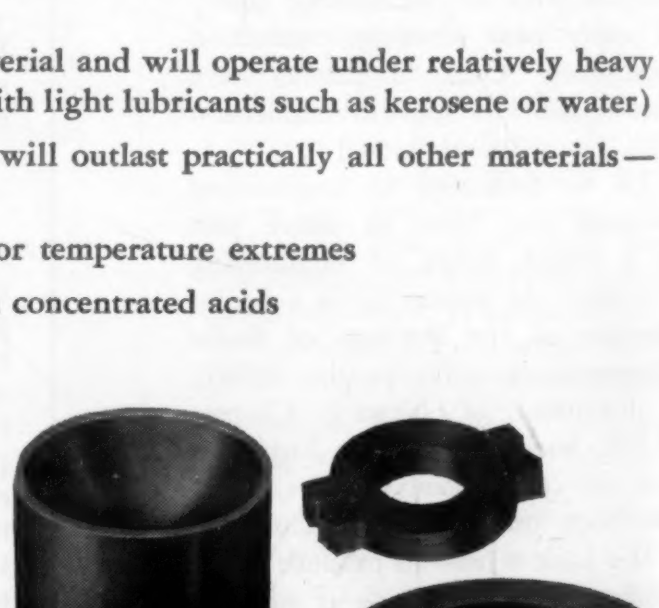
- chemically inert and will not corrode in contact with concentrated acids

In hundreds of difficult applications, GRAPHITAR has proved to be the only completely successful material; it has become practically indispensable to modern industry. GRAPHITAR parts can probably improve the performance of your products. For complete information, write for our 64-page GRAPHITAR catalog.



THE UNITED STATES

For more information, turn to Reader Service Card, Circle No. 481

—One Point of View

More Work, Less Talk

As custodian of this corner it is probably my duty to worry about things in general than might be normal to my make-up. Taking the duty seriously, I am now concerned about all of the loose depression and recession talk going about these days. Most of the talk is from economists who must be pessimists by nature.

It is perhaps too broad a generalization to state that all of the predictions made by economists are wrong—particularly those predictions as to the rise and fall of our economic fortunes. Many men made reputations as forecasters by calling the "crash" in 1929. However, the facts remain that many had predicted that same crash for 5 or 6 years and when finally the year hit, they were proclaimed as oracles.

Being ruled, in our emotions, largely by advertising and propaganda, we could probably be talked into a recession, or worse, if only enough people tell us we are bound to have one. Sure there has been some rise in unemployment, but there is another side of the picture. Personal experience has taught me that the buying of good furniture today entails a wait of about three months between order and delivery. A wait of several weeks is required to get some of the more popular of the new cars. Many business men are hollering "wolf" because new orders this year are only equal to those of last year, not twenty per cent greater.

One pundit has sounded a sensible warning about putting off the ordering of such staple supplies as steel for inventory. It is felt that there is a better than even chance that a steel strike will come about next June when labor contracts are being fought over. Any protracted strike could put many a business in a bad spot.

Possibly a moral to all this is: Don't talk depression, but devote those energies to building a better or less costly product so that your sales people will be able to offer better values. There is still a lot of business to be had if only the right approach is made towards getting it. And, not just incidentally, choosing the proper material can go far towards making a better or less expensive product.

The Materials Appeal

During one recent week New York was filled with shows devoted to transportation and/or pleasure. We refer to GM's Motorama and the National Motor Boat Show. One point of similarity, at least, existed in both shows. In both cases much ado was made over the use of plastics. All of the experimental models of automobiles had bodies made of glass reinforced plastics, and the world was made to know through newspaper ads and publicity, radio, television and the announcers at the show itself. Almost the same story could be told about the motor boat show, where, as one spokesman put it, there were enough plastics boats to hold a good sized show of their own.

Although favorable to plastics, we, at this moment, are not striving to advance their cause. We cite these situations to point out how important materials can be in the design and manufacture of products. In boats, plastics were chosen because they had many valuable service properties to offer. In cars they were used because of the ease, speed and economy of fabrication. They were selected in both cases because they had something to offer, not just because they had been publicized and glamorized.

I think we can look for many more shifts in materials usage as competition gets keener. There are still many unwise uses of materials, either because of lack of knowledge or lack of initiative in industry. In addition there are many prejudices against new materials.

T. C. Du Mond

How The Government Buys

by MARGARET P. HASKIN,

Purchase Specifications and Standards Branch, Bureau of Ships, Navy Department

PART 1 • FEDERAL AND MILITARY SPECIFICATIONS

This first of three articles explains the various types of government specs and how they are used. The other two articles will cover Qualified Products Lists, and Standards.

● FEDERAL AND MILITARY SPECIFICATIONS are usually referred to as "Government" specifications. However, they concern everyone having material, equipment or services to offer to the government under contract. It should be noted that nationally recognized industry and technical society standards and specifications are used to the greatest extent possible in the development of these so called "Government" specifications and in this way industry plays a large part in their development.

An effort is being made to reduce the number of specifications necessary for government procurement. As the first step, specifications used by the military departments are being limited where possible to two main series, Federal and Military. Individual activity specifications, such as those in the old Navy Department series, are being combined and incorporated into the Federal or Military series as rapidly as possible.

A specification is intended to be a clear and accurate description of technical and physical characteristics or performance requirements of the material or equipment, including preparation for delivery and procedures by which it can be determined that requirements have been met.

Federal Specifications

Federal Specifications cover supplies and materials of interest to and in common use by two or more government departments, at least one of which is civilian. These specifications are administered by the Director of Federal Supply, General Services Administration.

Federal specifications are identified by a symbol composed of three parts as follows:

1. An arbitrarily assigned single, double, or triple letter indicates the Federal "Group for Procurement". Actually, this is an alphabetical classification system. Examples: H—Brooms and brushes; FF—Hardware; LLL—Wood products.

2. A single letter which is the first letter of the first word in the title.

3. A serial number determined by the alphabetical location of the title. Examples of identifying symbols of Federal Specifications are: H-B-695—Brushes, varnish, flat. FF-P-101—Padlocks. LLL-B0636—Boxes, fiber, solid (for domestic shipment).

Federal specifications are of three types as follows:

Regular (*coordinated*) — Have been circulated and approved for use by all interested Government departments.

Interim — Are developed and issued by an individual government agency to satisfy an immediate need. They are mandatory for use by the specific agency or agencies indicated in the preamble but are optional for use by other federal agencies. Interim Federal specifications are intended for final processing as regular Federal specifications, and, prior to coordination are identified by the basic symbol prefixed with double zero (00) and carry a suffix to identify the issuing activity. Example: G G - C-00191 (Navy-BuMed) — Generator, Ultra-violet, Physiotherapeutic.

The preamble, which is located on the first page of interim Federal specifications directly under the title, explains the significance of the specification. In cases where it is intended that the specification when coordinated will supersede an existing regular Federal specification, this will be so indicated in the preamble. Example: "This interim Federal Specification has been developed by the Navy Department, Bureau of Ships, based upon currently available technical information. It has not been approved for promulgation as a revision of Federal Specification GGG-J-51a dated 9 September 1942, and is subject to modification. This specfication is in interim form only, and pending its promulgation as a regular Federal specification, it may be used in procurement."

Emergency—Specifications are designed for the primary purpose of conserving critical materials. They carry the same number as the basic specification; however, the basic number is prefixed with a zero. Emergency Federal specifications do not modify or supersede the basic specifications, but are issued in addition thereto, to be used as an alternate whenever possible to effect conservation.

When emergency specifications are issued, a "Notice" is published calling attention to the optional specification and the material it is intended to conserve. The notice carries the same symbol as the basic specification. Beneath this symbol appears the number and date of the notice. Notices to a particular specification are numbered consecutively using Arabic numerals be-

ginning with number 1. For example, the second notice to H-B-491b is:

H-B-491b
April 3, 1945
NOTICE 2
November 14, 1951
SUPERSEDING
NOTICE 1
October 5, 1951

A revision of a Federal specification supersedes entirely the previous issue including any amendment thereto. Revisions are indicated as follows:

Regular — Revisions to regular Federal specifications are indicated by the addition of a small letter—a, b, c, etc.—to the symbol in the upper right hand corner of the first page. Example:

QQ-B-746a
8 October 1950
SUPERSEDING
Fed. Spec. QQ-B-746
June 5, 1934

Interim—Different methods are used to indicate revisions of interim Federal specifications. Among these are superseding by date only, and the use of revision letters as described for regular Federal specifications.

Minor changes in a Federal specification are made by amendment. These bear the specification symbol, the amendment number and date in the upper right-hand corner. Only one amendment is in effect at any time; subsequent changes in the specification are made in a superseding amendment that includes all changes to the date of its issue. Superseding amendments are indicated by the figure "2", "3", etc. Example:

J-C-103
Amendment—5
27 May 1950
SUPERSEDING
Amendment—4
April 4, 1947

Suffixes for Identification of "Limited Coordination" Specifications

	Army
CmlC	—Chemical Corps
CE	—Corps of Engineers
Med	—Army Medical Service
Ord	—Ordnance Corps
QMC	—Quartermaster Corps
SigC	—Signal Corps
TC	—Transportation Corps
	Navy
NAVY	—Department of the Navy
Aer	—Bureau of Aeronautics
MC	—Marine Corps
BuMed	—Bureau of Medicine and Surgery
NOrd	—Bureau of Ordnance
Pers	—Bureau of Personnel
Ships	—Bureau of Ships
S&A	—Bureau of Supplies and Accounts
Docks	—Bureau of Yards and Docks
	Air Force
USAF	—Department of the Air Force
ASG	—Aeronautical Standards Group

Military Specifications

Military specifications, formerly known as Joint Army-Navy (JAN) Specifications, cover those materials, products or services used solely or predominantly by military activities. While the use of these specifications is required only for military activities, they may be used by other federal agencies if desired.

These specifications issued first through the Joint Army-Navy Specifications Board as "JAN" specifications, were continued by the Munitions Board Standards Agency (MBSA) and later by the Defense Supply Management Agency (DSMA) in the same non-significant numerical sequence, with the only change being the adoption of the prefix "MIL", although the number remains the same. This numbering system has also been retained by the Office of Standardization (successor to DSMA) which now has the responsibility of administering Military specifications and standards.

One of the responsibilities of the Office of Standardization is direction of the Department of Defense standardization program. The program pertaining to military specifications is directed toward:

1. Determination of the least number of types of items required to fulfill the needs of the armed forces.
2. Attainment of the greatest practical degree of uniformity and interchangeability in component parts.
3. Attainment of highest practical degree of standardization in processes.
4. Establishment of standards and specifications to insure purchase of only such items as meet requirements essential to the armed forces.
5. Use of uniform terminology in defining technical and engineering practices and principles.

Military specifications are intended to cover military requirements insofar as technical developments and current industry practices permit. Changes in specifications are made whenever warranted by technical progress, experience in manufacture, or experience in the use of the item covered. Under this policy, no military specification is final or restricts technical development and improvement of design.

Military specifications are of two types, "coordinated" and "limited coordination". "Coordinated" specifications are concurred in by the three military departments and cover items of common use. "Limited coordination" specifications are those of single departmental interest.

Coordinated specifications are identified by a symbol composed of three parts; the letters "MIL" (abbreviation for Military) followed by a single letter, which is the first letter of the first word in the title, and a serial number. For example the symbol for the specification covering chair, wood, steamer type, is MIL-C- (for the word "chair") 852 (serial number). As existing specifications carrying the prefix "JAN" are revised, the prefix is changed to "MIL" although the number remains the same.

Limited coordination specifications are identified by a suffix to the basic symbol, which identifies the activity issuing it. For example: MIL-C-852 (SHIPS). If a limited coordination specification later becomes coordinated, the suffix is dropped.

If a coordinated specification becomes obsolete and revision is delayed, a "limited coordination" specification may be issued to cover changes required. To avoid confusion, it may be issued under the original number. These specifications, in addition to the regular identification carry the notation "Used in Lieu Of" and symbol is prefixed with a double zero (00). Example:

MIL-R-0016847C(SHIPS)
6 March 1953
Used in Lieu Of
MIL-R-16847B
11 July 1952

A specification with the words "Used In Lieu Of" must be used by the issuing activity. The coordinated specification is active until completely superseded, for activities not desiring to use the limited coordination specification.

Revisions of Military specifications are indicated by a capital letter following the symbol and preceding any suffix. The first revision is marked with the letter A. Succeeding revisions are marked by the other letters in alphabetical sequence except that I, O, Q and S are not used.

For example: MIL-W-17000A or MIL-W-1700B(SHIPS)

As in the Federal specifications, minor changes to Military specifica-

tions are made by amendment. These bear the specification symbol, amendment number, date and any supersession notice in the upper right hand corner. Only one amendment is in effect at any time for a specification.

A custodian from each of the military departments (Army, Navy, and Air Force) is designated for each specification. In general, custodianship is based upon technical responsibility and the assignment is made to a technical service or bureau. Custodians must determine that the requirements of the specification satisfy the needs of their department. Either custodians prepare the specification or it may be assigned to a joint agency such as the Aeronautical Standards Group. Custodianships are shown on the last page of the specification. Other interest within the Army and Navy is shown by symbol. For example:

Custodians:

Army—Ordnance Corps
Navy—Bureau of Ordnance
Air Force

Other Interest:

Army—EST
Navy—AOSY

Questions concerning Military specifications listed in a particular contract should be referred to the purchasing officer. Questions concerning Military specifications not involving a contract should be referred to the appropriate departmental custodian, bureau or service indicated in the specification.

Format of Specifications

The format of Federal and Military specifications is essentially the same. Federal specifications are divided into seven general sections, Military specifications into six, as follows:

Federal

1. Scope and classification.
2. Applicable specifications, other publications, and drawings.
3. Material requirements.
4. Sampling, inspection, and test procedures.
5. Preparation for delivery.
6. Notes.
7. Departmental requirements.

Military

1. Scope
2. Applicable specifications, standards, drawings, and publications.
3. Requirements.
4. Sampling, inspection, and test procedures.
5. Preparations for delivery.
6. Notes.

Section 1 contains general information on the applicability of a product or service covered by the specification, and when necessary, specific classification breakdowns.

Section 2 contains a listing of the documents referenced in the specification, and information on sources of copies.

Section 3 contains essential requirements and descriptions applying to the material or product covered by the specification. This section indicates as definitely as possible, the standard of performance, quality, and workmanship which the commodity must meet. Where qualification approval is required, section 3 contains a statement to that effect.

Section 4 includes detailed information on methods and frequency of sampling, inspection, and tests to determine conformance of products presented for acceptance under the specified requirements.

Section 5 covers the requirements for preserving, packaging, and packing the item, including specific requirements for materials to be used.

Section 6 contains information of a general nature not properly part of the preceding sections. This includes use or application notes and detailed information to be incorporated in invitations for bids, contracts or other purchase documents.

Section 7 (Federal only) contains special requirements for individual departments. These requirements take care of administrative problems caused by the different uses of the item in various Government departments.

Indexes

The General Services Administration "Index of Federal Specifications and Standards" is a complete listing of all Federal specifications and standards issued under GSA auspices. Copies of the Index and Monthly supplements may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The Military index of specifications is divided into four volumes. However, Volume I which was issued by the Munitions Board Standards Agency has been temporarily discontinued. The other volumes are as follows: "Index of Specifications and Standards, Used by Department of the Army, Military Index, Volume II.", "Index of Specifications and Standards, Used By Department of the Navy, Military Index, Volume III.", "Index of Specifications and Related Publications, Used by Department of the Air Force Military Index, Volume IV."

Volumes II, III, and IV list the Federal and Military specifications approved for use by the particular Department. In addition, they list individual bureau and service specifications still current, not yet included in the Federal or Military series. Copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Obtaining Copies of Specifications

Copies of Federal Specifications may be obtained upon application, accompanied by remittance to the General Services Administration, Business Service Center, Region 3, Seventh and D Streets, S.W., Washington 25, D. C. This office will also honor deposit account numbers issued by the Government Printing Office. Single copies of Federal product specifications required for bidding purposes are available without charge at the GSA Regional Offices.

Copies of individual specifications used by Army and Air Force may be obtained as noted in the foreword in the applicable Index volume.

Copies of specifications used by the Navy, listed in Volume III of the Index may be obtained upon application to the Commanding Officer, Naval Supply Depot, Scotia 3, N. Y. except for specifications in the Military series bearing numbers 5000 to 9999 and designated by the letter "A" only in the "Activities concerned" column of Volume III which are referred to as aeronautical items. These specifications are issued by the Technical Records Division, United States Naval Air Station, Johnsville, Pa.

Information on specifications issued by individual bureaus, services or activities in other than the Federal or Military series should be requested from the issuing activity.

In requesting copies of specification or other documents, title and number should be given. In requesting classified specifications or specifications believed to be inactive, the reason for requesting should be given. This will assist the issuing activity in identifying the specification and in the case of restricted distribution eliminate additional correspondence.

New Epoxy Primer Has High Resistance to Alkalies

Sanding baked epoxy finished parts to remove minor irregularities.

Advanced flow coating technique combined with new primer . . .

- ***Permits thinner film thickness***
- ***Improves corrosion resistance three times***

by H. L. FARBER, Supervisor, Quality Control Dept., Westinghouse Electric Corp., Mansfield Plant

● IN NO OTHER BRANCH of the appliance industry has the problem of adequate protective finish been more severe than that of the washing machine producers. Resistance to alkalies and new, effective, but film penetrating detergents, when compounded with field service conditions, particularly in the South, Coastal and Gulf areas, represent a continuous and costly problem.

A major step in the solution of this problem has been taken by most manufacturers in the specification of appliance primers formulated by leading paint manufacturers and based on newly developed epoxy resins. This new type of primer provides greatly increased resistance to attack from moisture, alkalies and detergents and shows better adhesion to the base metal than previously used alkyd primers.

An outstanding example of this development is its application to the Laundromat at Westinghouse Electric Corp. plant in Mansfield, Ohio. Here, a primer coat solution, based on Shell Chemical Corp.'s Epon epoxy resin and formulated by Pittsburgh Plate Glass Co., is flow coated on the washing machine components that are exposed to corrosive and chemical attack. The current primer is less than 1/3 the film thickness of the alkyd primer previously used and production parts as well as test panel results indicate a three-fold improvement in resistance under rugged conditions.

The Coating

The epoxy resin, the basic resin in the primer, is essentially a condensation reaction product of bisphenol and epichloro-hydrin. Effective molecular linkage in these resins is the stable ether type rather than the ester linkage typical of alkyd resins, and provides their unique chemical and corrosion characteristics.

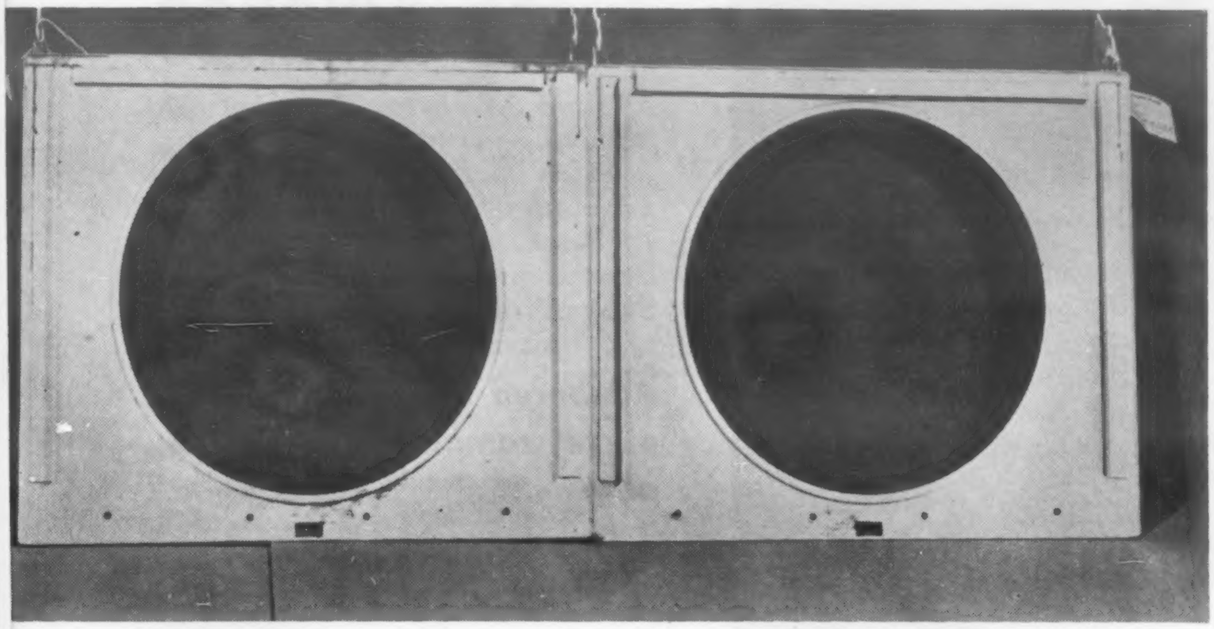
Before the switch was made from sprayed alkyd primers to flow-coated epoxy primers, comparative tests of various alkyd and epoxy resin formulations were made. Westinghouse put many paint manufacturers' primers through salt spray tests (200 hr), humidity tests (100% at 100 F) and immersion tests (salt and detergent for 380 hr at 140 F) before finding the primer giving most satisfactory results. While the epoxy-ester primers showed superior results over alkyd, the epoxy-urea systems showed a cumulative list rating of 9.5 (10 being perfect) as against 3 for the alkyd.

Production Steps

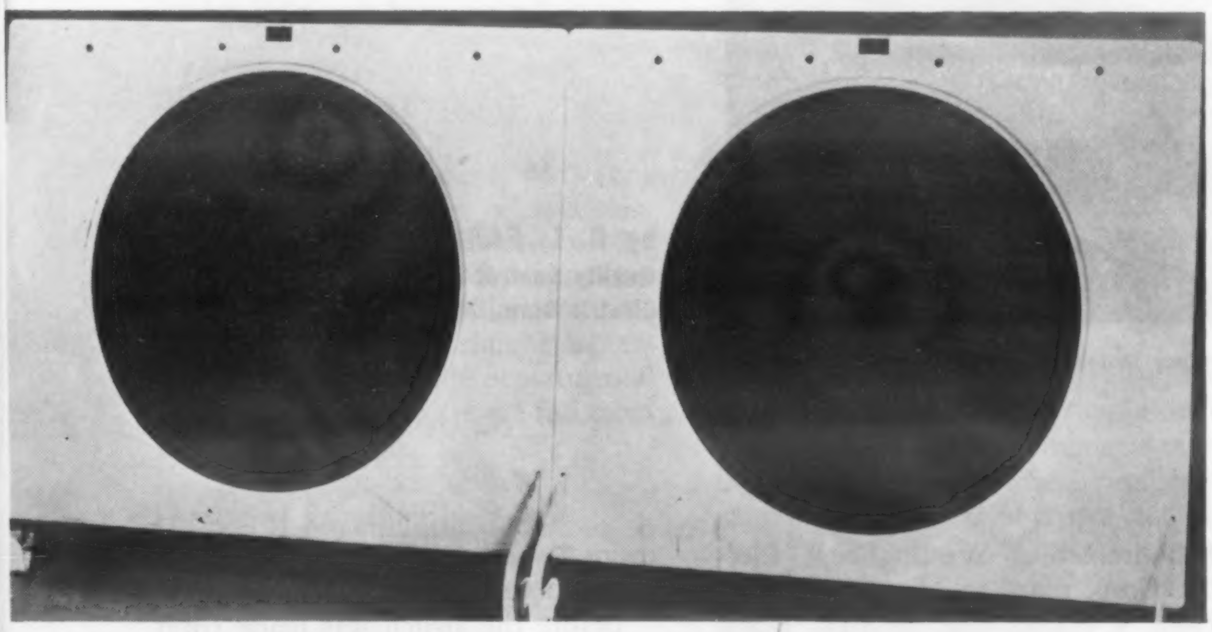
Specific components of the washer to receive the new primer are the top, front, door and lower front panel,

RESULTS OF 200 HR SALT SPRAY TESTS

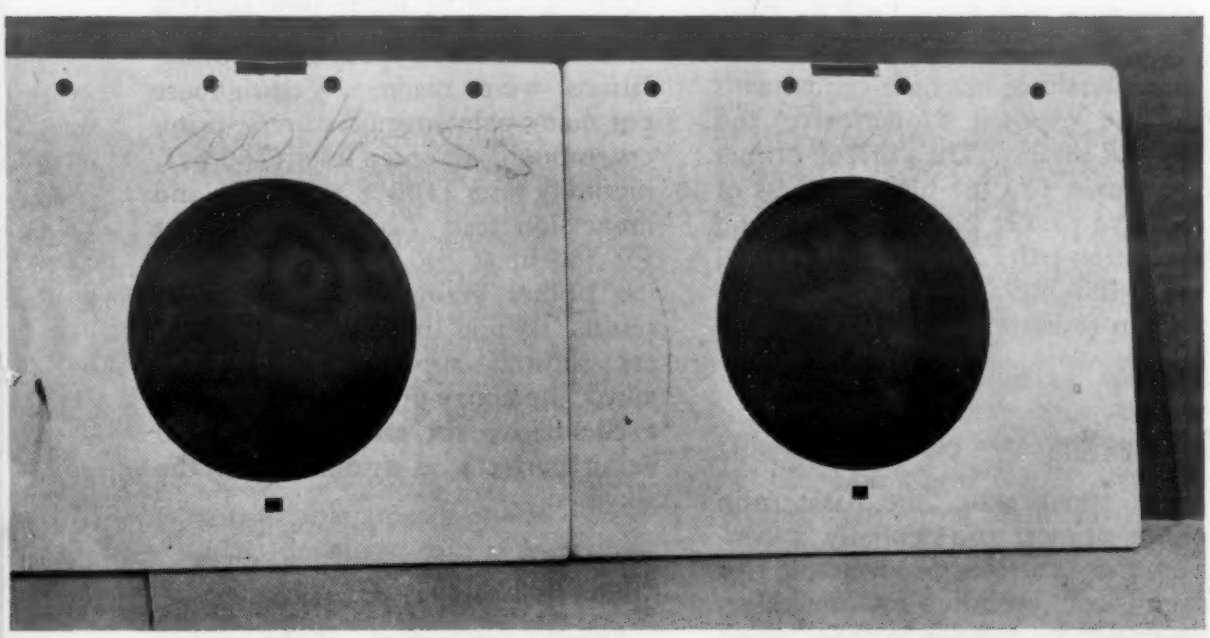
Alkyd Primer | *Epoxy Formulation*



Inner Door Panel



Top Side Inner Door Panel



Outer Door Panel

bracings, clamps and bottom pan. Some of the interior surfaces receive a coat of the primer as their only finish.

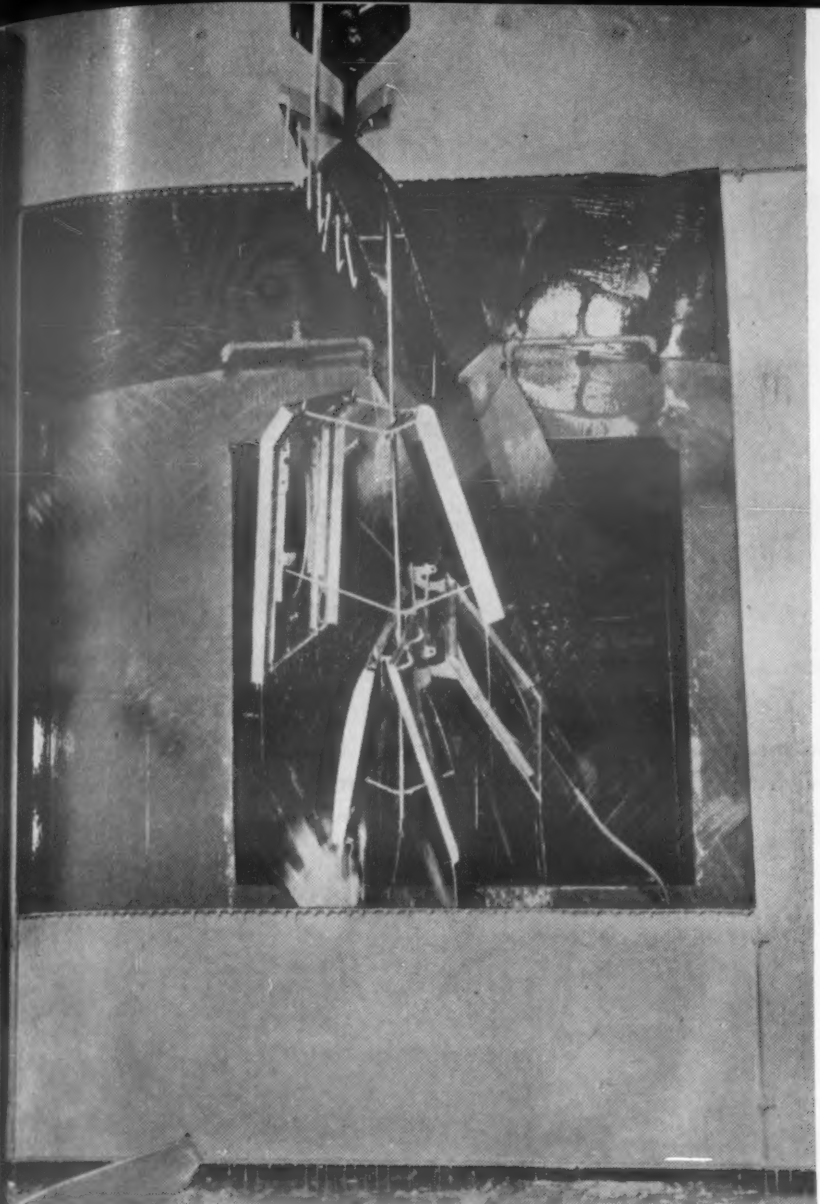
On the production line at Westinghouse, the primer and thinner are premixed in an agitator mixing tank, using 106 gal of gray Epon epoxy primer and 53 gal of special thinner to obtain a viscosity of 24 sec at 80 F. The mixed material is then pumped to the paint tank outside of the flowcoater. This mixing operation could be handled directly in the flowcoater paint tank if desired.

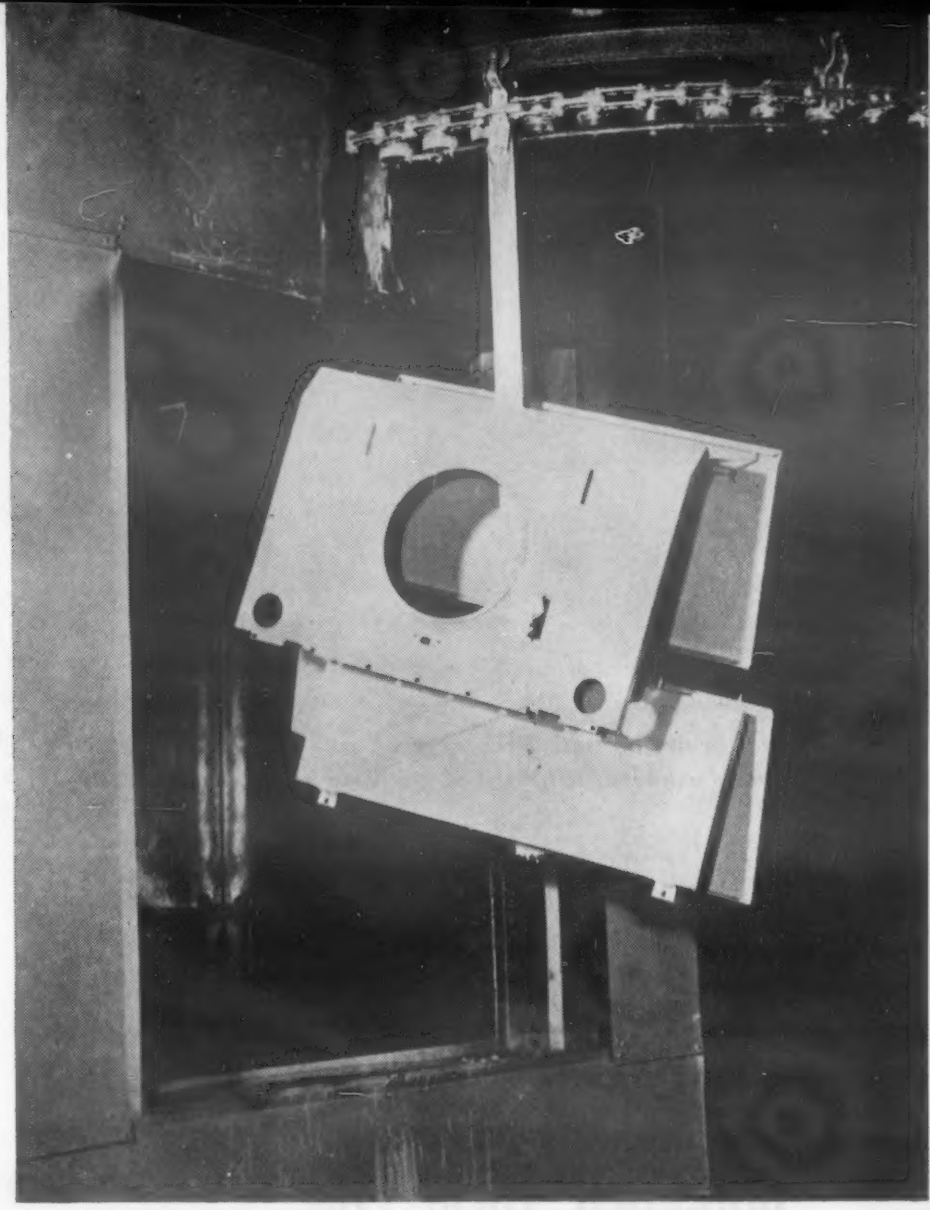
After the Laundromat parts, which have been conventionally cleaned, bonderized and acid rinsed, are flow coated at a conveyor speed of 10 ft per min, they are allowed to drain for about 18 min. Following this, they are baked for 15 min at 375 F.

Primer film thickness of 0.3 mil is maintained throughout the flow coating (as against the 1 mil alkyd coating required). This thinner coating is less susceptible to variations and ridges and requires a minimum of sanding. The thinner film, plus the effective application method, also provide more dependable and uniform coverage of bends, curls, corners and other hard-to-get-at areas in the metal components—usually the points most susceptible to failure and "edge creepage" of corrosion. Special racks were designed for hanging each part in order to realize maximum flowing properties and film uniformity—with a minimum of "tears" or drip edges.

The flow coating of the new primer represents considerable man-hour and paint savings over the spray coating employed with the previously used alkyd primer. The new primer also provides maximum gloss, abrasion resistance, grease resistance, flexibility and "holdout" for the white baking enamel used on all Laundromat equipment.

Primers and appliance finishes based on the new epoxy resins are not only being used by washing machine manufacturers, but are spreading to meet finishing requirements in all branches of the appliance industry. The excellent physical and chemical properties of these resins are responsible for their wide acceptance in the appliance industry and for their growing service in a variety of protective surface coatings, from plant maintenance finishes to can and tank car linings, in industries involving chemical, corrosive and wear hazards.


Washer parts receiving flow-coat application of epoxy primer. Operation takes less than one minute.


Flow coated parts leaving draining section and about to enter baking oven. Note angle of hanging which permits draining towards one point.

Advanced Flow Coating Techniques Used

Much of the success of this epoxy primer application is attributable to the flow coating techniques used.

After careful study it was found that, with some changes, conventional flow coating equipment, such as the Spra-Con Flowcoater, was entirely suitable. One view was that a solvent-saturated atmosphere was necessary in the "drain-off" area (the enclosed section immediately following the flow coating section and prior to baking). Yet, production dip application tests indicated that the primer had very satisfactory flowing characteristics in normal room atmospheres, and that a solvent-saturated atmosphere is neither desirable nor necessary when this type of primer is used.

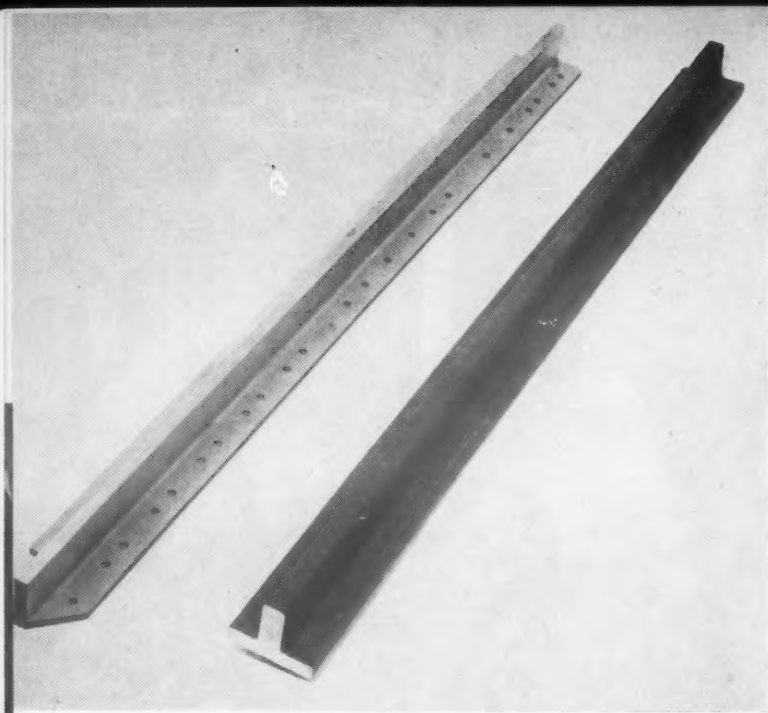
Westinghouse solved this problem by building in a "vestibule enclosure" immediately after the actual flow-coating section in order to confine the solvent vapors collecting in the "drain-off" area. In addition, the front exhaust air duct and the air slots in the exhaust duct at the exit end of "drain-off" chamber were closed, thus eliminating the probability of a fresh air seal at the entrance and exit ends of the flow coater, in this way making possible actual removal of a greater volume of solvent vapors from the interior "drain-off" area itself.

These changes resulted in a very satisfactory application job, despite the highly active solvents used, thus allowing the superior resistance of this type primer to soaps, detergents, salt spray and humidity to be utilized.

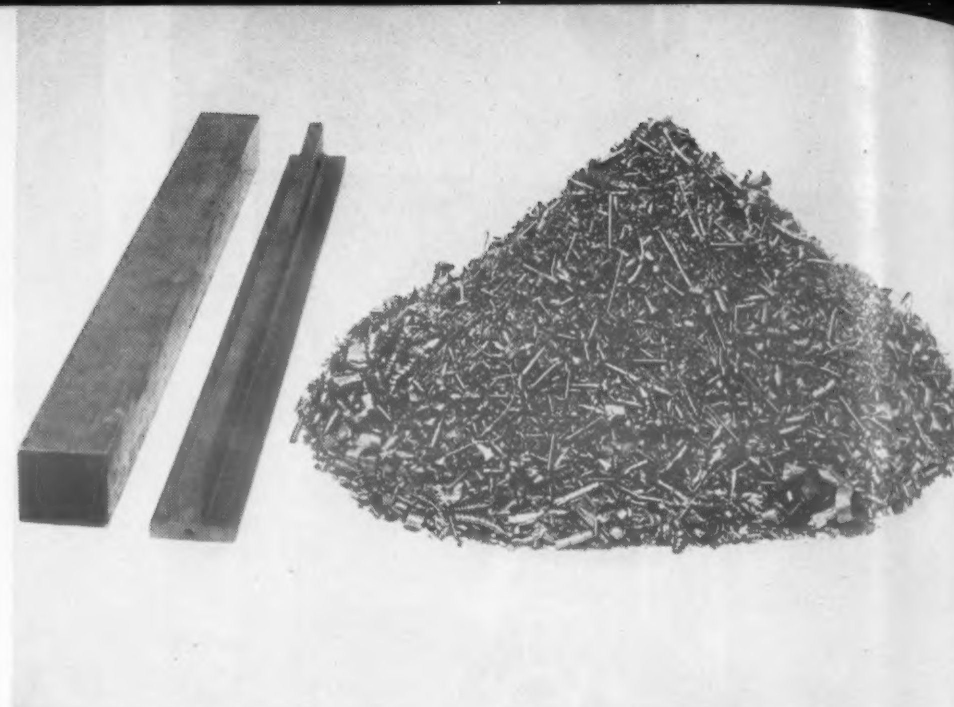
The equipment to apply the primer also represents the latest development in flow coating technique, using revolving arms along with the stationary system. Each flowcoater requires only a spinner with two nozzles on each side of the unit, a 2-nozzle spinner on the bottom, along with two stationary nozzles set at an angle for cross-spraying upward, and, on the top, four stationary nozzles spraying down. Thus 12 nozzles give the same work coverage as many more stationary nozzles; and at the same time they permit less aeration of paint and, consequently less solvent loss.

Paint loss in general is less with the rotary type applicator and paint is more easily applied to hard-to-reach areas. Speed and adjustment of the rotating nozzles are easier to control and allow a more flexible work pattern.

Stationary nozzle positions are usually adjusted when the flow coater is installed and ordinarily need no further manipulation. The lowest possible fluid pressure is employed for each nozzle, since atomization is not desirable and the lower the pressure, the less splattering and solvent vapor loss. In the Westinghouse flowcoater, complete coverage is being realized at fluid pressures approximating 10 lb each, but actual pressures must be determined for each flowcoater and the type parts being finished. For maximum film uniformity and minimum solvent loss, the selection of a proper reducing solvent—easy to control from the standpoint of viscosity and evaporation rate—is important.



An aircraft flap track made of steel extrusion. Right, part as extruded; left, finished machined part.



Big savings in machining costs are realized through use of hot extrusions. Left, size of bar needed if flap track is machined from bar stock, and, right, amount of resulting chips. Center, part produced as a hot extrusion.

Hot Steel Extrusions

CONSIDER THEM FOR

- *Shapes too complex to roll*
- *Shapes from alloys too brittle to roll*
- *Small lots of special shapes*

THEODORE B. MERRILL, JR. Assistant Editor, Materials & Methods

● THE USE OF hot-extruded high-alloy steel has cut the cost of a machined part for the Lockheed Constellation by two-thirds. A similar substitution has resulted in a real savings of almost three to one in the cost of a flap track for the Northrup F-89.

The announcement of these econimies is the first evidence that hot extrusion of high-alloy steel has progressed from the experimental stage to practical production use. Also, until the application of extruded steel shapes in the Northrup Scorpion and the Super Constellation, the new method of shaping steel had not been applied to aircraft components.

The unorthodox method of fabrication is considered a long step forward in the industrial use of high-alloy steel. Harvey Aluminum, producer of the extrusions, predicts a bright future for the process. They point to cost savings over expensive methods of machine milling, savings in materials and greater speed of manufacture.

Savings Realized

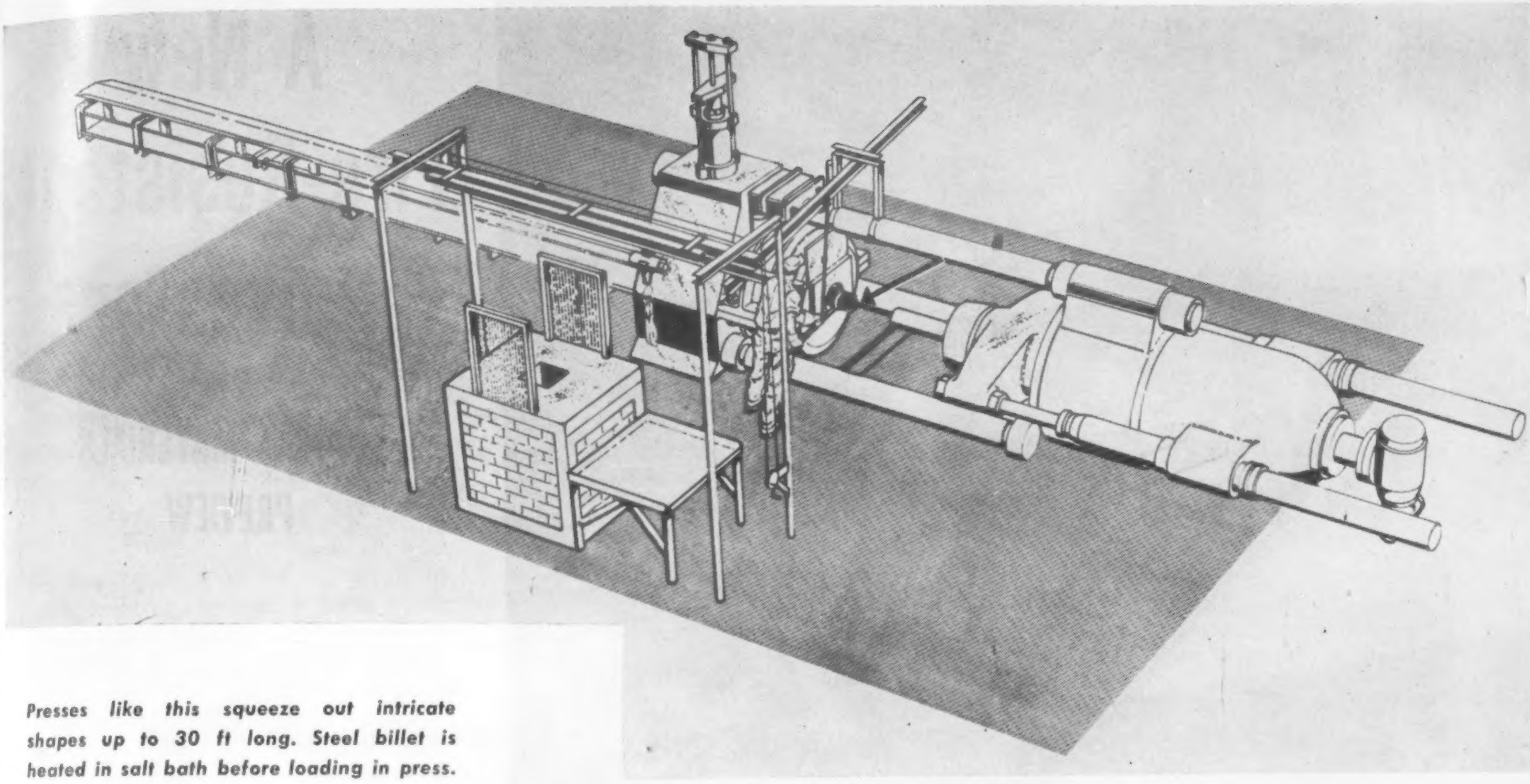
The extruded part for Lockheed is an 8630 steel radome attachment bracket. The extrusions are cut into 5-in. lengths, drilled and installed on the Super constellations without further machining. The cost of the extruded part is spectacularly less; the finished product now costs $8.90, while the same part made by machining cost $29.40.

The F-89 flap-track extrusion is a good example of reduction in scrap waste. The part is cut from 15 ft extrusions of type 4340 steel. The extrusion area of the die is 1.30 sq in., exactly equal to that of the finished part, while the rod bar, from which the part was machined, had a cross section of 3½ sq in. Weight of a 2 ft length of the extrusion, in effect a finished part, is 8.84 lb compared to 26.3 lb for an equal length of bar stock before machining. Thus there are two pounds of chips saved for each pound of finished product.

The waste savings inherent in extrusions are readily translated into significant advantages of labor, time and materials conservation and consequent reduction in ultimate cost. There are other advantages to the process which should be considered, such as the volume fabrication of shapes too complex to be rolled, the possibility of shaping parts from alloys too brittle to be rolled and the production of small lots of special shapes due to the low costs of extrusion dies.

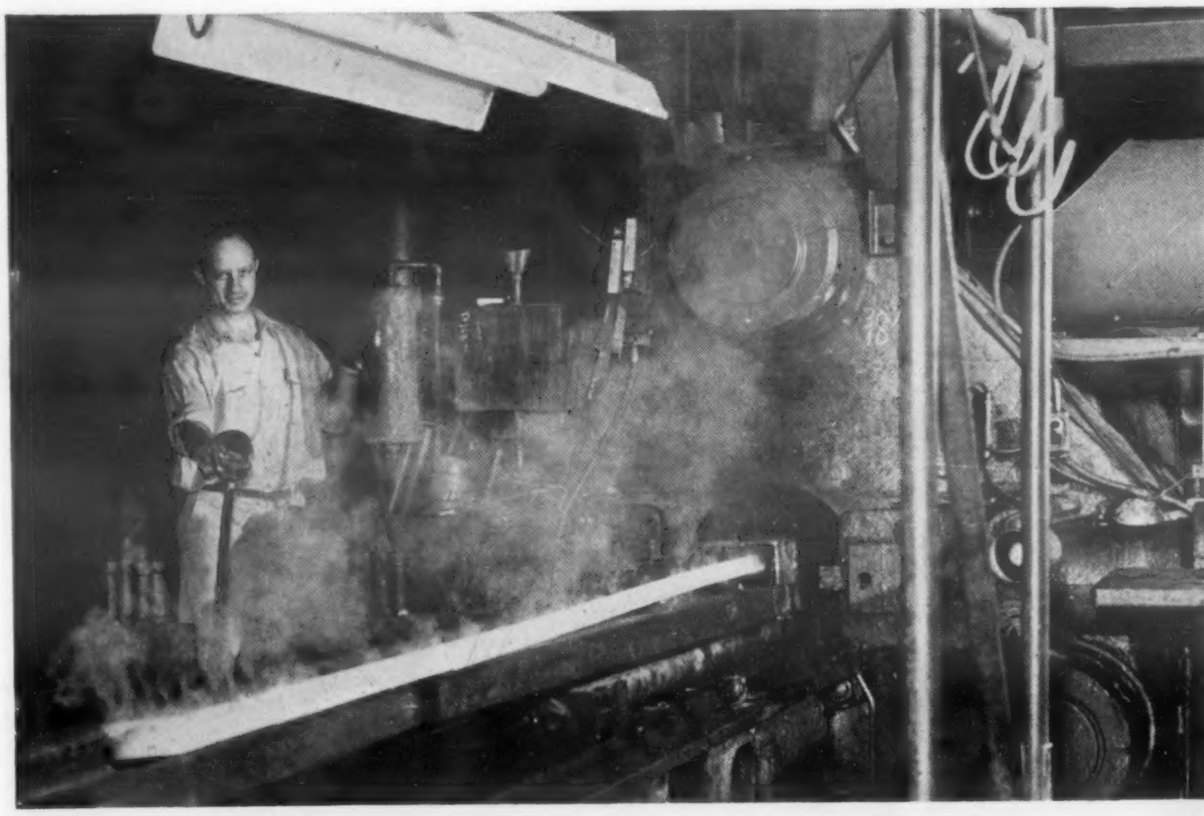
Small Orders Possible

According to Harvey, it is entirely conceivable that a manufacturer could afford to order as little as 50 ft of a special alloy steel extrusion, with a die cost of between $200 and $500. Such and order would, of



Presses like this squeeze out intricate shapes up to 30 ft long. Steel billet is heated in salt bath before loading in press.

Steel extrusion coming from 1650 ton hydraulic extrusion press.



course, be uneconomical for fabrication by rolling, as costs for rolls would be around $30,000. It is somewhat doubtful that a 50 ft order could compete with machining, but the example does suggest that the difference in die costs between extrusion and rolling would appear to be enough to offset the longer life of rolling dies.

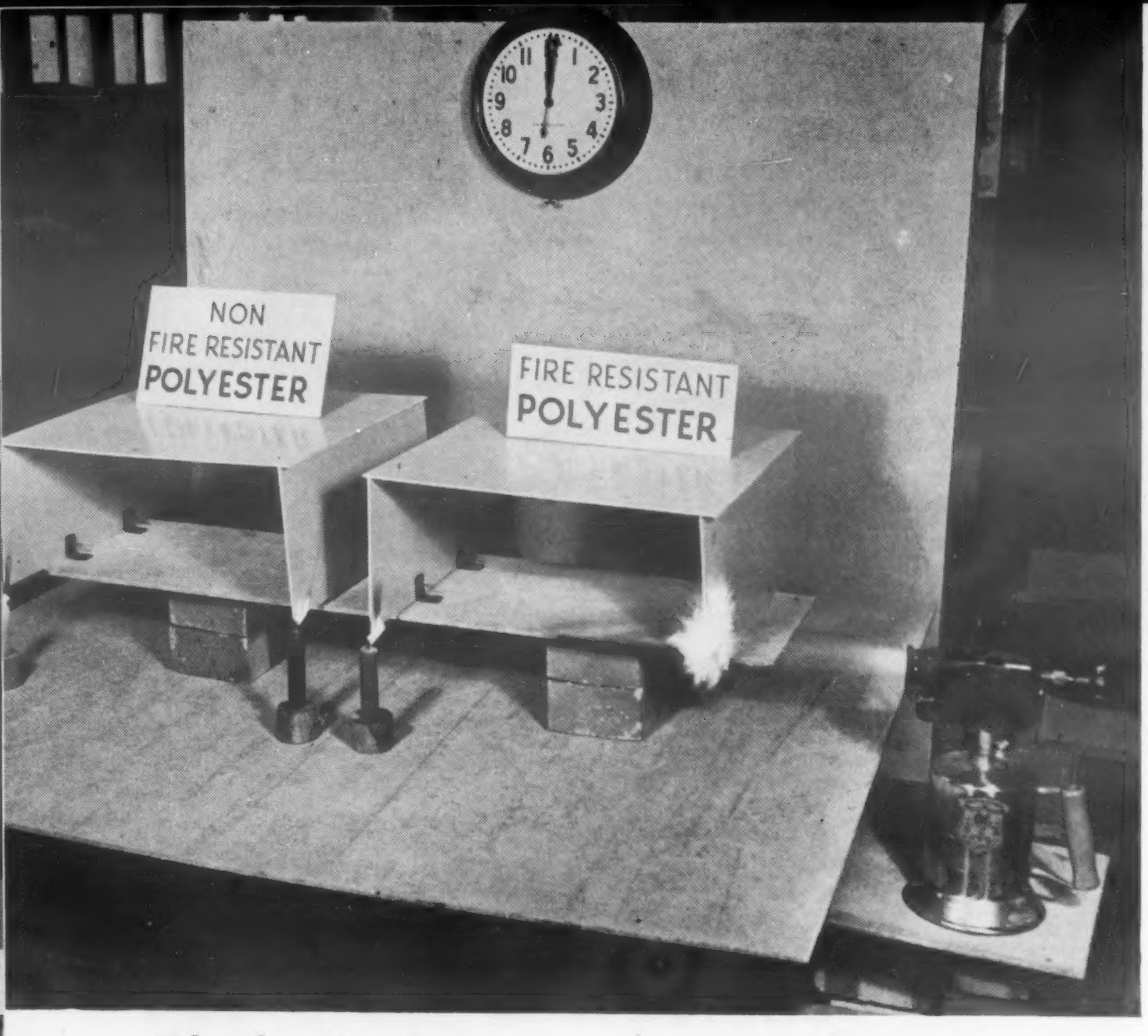
Extrusion of metal is common in American industry, but the overwhelming majority of extruded parts are made of aluminum, and comparatively small quantities are of such metals as brass and copper. Harvey Aluminum carried out its original hot-steel extrusion research work under an Air Force-Lockheed Contract. Initial success stimulated further developments for the aircraft industry and for the industry at large.

The difficulties in hot-steel extrusion have stopped a number of attempts to squeeze the metal through holes. There has been little difficulty in forcing hot steel to flow through die openings, as steel is one of the best hot-working materials and in its plastic stage has much better flow characteristics than aluminum. The complications in steel extrusions have been due largely to the effect of high temperatures on die materials. Previous attempts to extrude steel have failed to maintain dimensional tolerance and/or physical properties.

The present solution to hot extrusion problems is credited to the development of a superior die material and the perfection of a more effective lubricant to prevent the die surface from the molten steel. Molten glass has been a promising lubricant in the past, as it is one of the few materials that will neither combine with the steel or the die, and will not burn away.

Harvey revealed that teemperatures up to 2300 F are necessary to get proper extrusion characteristics with intricate die shapes. Current production projects call for billets of 6-3/8 in. dia and pressures to 150,000 psi.

Aluminum presses were modified to convert to hot steel. Ram speed was increased and the ingot container had to be rebuilt to handle higher temperatures.



The beginning ...

... and the end **of a demonstration on fire-resistance of polyester glass. Flame sources on the left were removed after ignition. Laminate on the right is made with one of the new Hetron resins.**

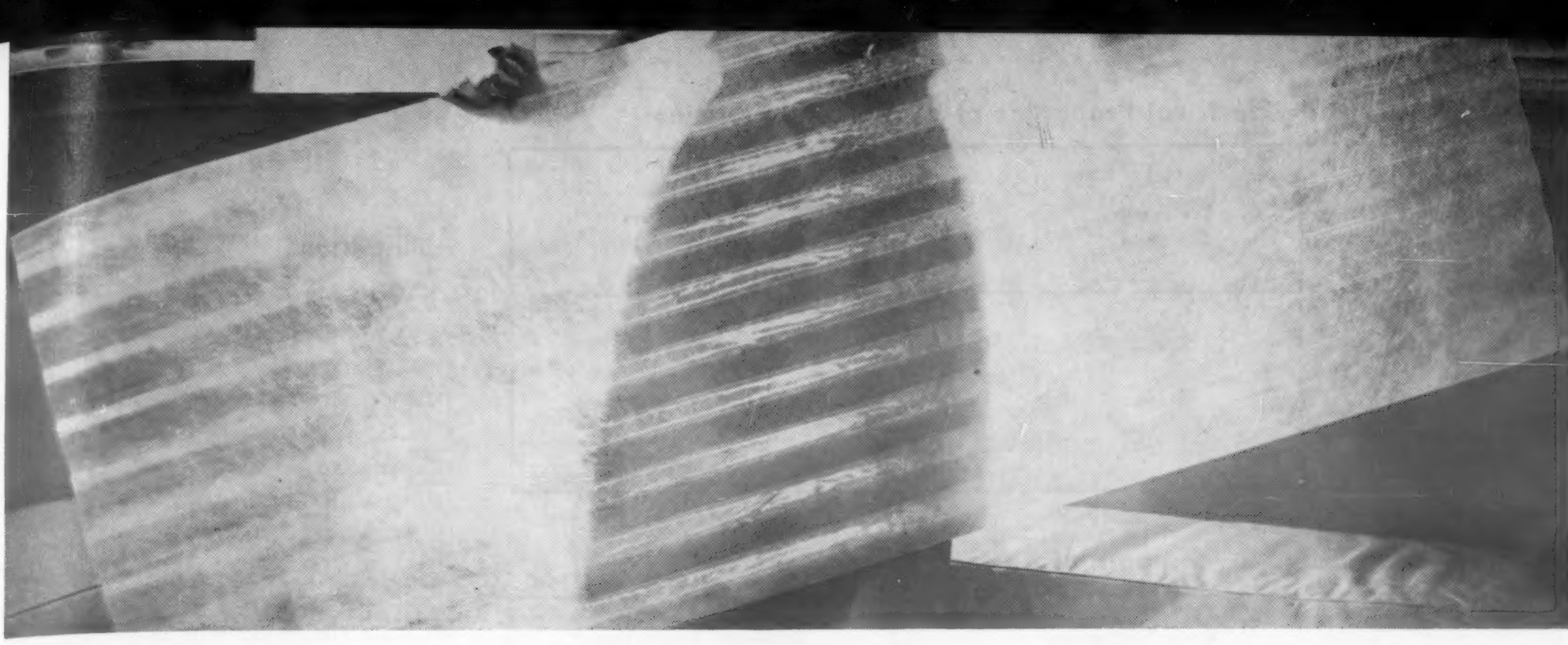
A New Fire-Resistant Polyester

—NEW MATERIALS PREVIEW

Most of its service and fabrication properties are at least equal to those of conventional polyesters. . . . At present higher cost will limit it to uses where fire-resistance is required.

● THE RELATIVELY LOW fire-resistance of conventional polyester resins has restricted the applications for glass-reinforced laminates to some extent. Even with a high proportion of mineral filler and anitmony oxide, most polyester resins fail to meet standards of fire-resistance that are necessary or at least desirable for some otherwise appropriate uses. Moreover, high proportions of filler destroy the translucency which is an important characteristic of these laminates in many nonstructural applications.

These difficulties appear to have been overcome to a considerable extent by the development of a new class of polyester resins known commercially as Hetron and marketed by the Hooker Electrochemical Co. As measured by the flame spread test (ASTM E-84), laminates made with these resins and without filler have demonstrated fire-resistance markedly superior to conventional laminates containing high proportions of filler.



CORRUGATED ARCHITECTURAL SHEET is reportedly the largest single use for polyester-glass. A material sufficiently fire-resistant to get building code approval for interiors would greatly expand this application.

With a small amount of antimony oxide, Hetron laminates have given values good enough to apparently qualify it as an acceptable interior material under most building codes (see Table 1); for some codes no additions would be required.

This high degree of fire resistance, together with other improvements in service and fabrication properties, has been achieved, for the most part, without sacrificing other desirable properties. The base for this new series of resins is a new, stable dibasic acid, tradenamed Het Acid by Hooker, and having the formula: $C_9H_4O_4Cl_6$. This heavy molecule (molecular weight 389) reacts smoothly with the usual glycols and with maleic or fumaric acid to form an integral part of the polyester chain which may then be cross linked with styrene, vinyl toluene, diallylphthalate, triallyl cyanurate or other common agents. Het Acid contains about 55% chlorine by weight, and resins based on it may contain over 50% by weight of Het Acid. Hence, chlorine contents as high as 30% can be obtained in a resin, and it is this fundamental difference in chemical composition that distinguishes Hetron from other resins.

Table 1—Flame Spread Ratings of Various Materials
(Tunnel Test, ASTM E-84)

Material	Flame Spread Rating
Asbestos Cement Board	0
Flame Resistant Treated Plywood	35
Hetron 92-Fiberglas Flat Panel (with filler)	36*
Hetron 92-Fiberglas Corrugated Sheet (no filler)	69*
Red Oak	100
Cellulose Board	225
Veneered Wood	515

In this test panels containing conventional polyester resins, unfilled, were considerably inferior to cellulose board; those containing filler were slightly superior to cellulose board but inferior to red oak.
** Flame spread was in short burst. Panels were self-extinguishing and carried no flame for the final 6 to 7 min. of the 10-min. test.*

Fabrication Properties

Viscosity—Fire-resistant resins with room temperature viscosity as low as 1 poise can be made, but present grades range from 10 poises up. The rapid drop in viscosity with rise in temperature is illustrated in one grade by a viscosity of 30 poises at 73 F, 16 at 90 F and 7 at 110 F.

Air Inhibition—The rigid and semi-rigid resins cure tack-free in contact with air and show no air inhibition. The most flexible grades show some surface tack and are slightly air inhibited.

Gelation—SPI gel times ranging from 3 to 20 min are obtainable.

Inhibitors—Various inhibitors conventionally used in the polyester resin industry give good results.

Pigments—No unusual problems.

Promoters—Conventional response.

Release Agents—No unusual problems.

Pot Life—Excellent. Pot life of a typical resin catalyzed with 1% benzoyl peroxide is 7-12 days at 73 F.

Storage Stability—Most grades have a minimum storage life of 6 mo at room temperature in opaque containers.

Styrene Compatibility—The resins studied to date are completely compatible with styrene, although further dilution with styrene is not recommended where maximum fire-resistance is desired.

Glass wetting—Excellent.

Fillers—The new resins can be used with all conventional fillers.

Paintability—Unlike many resins in which fire-resistance is achieved by relatively volatile additives, the new resins hold a paint film as well as conventional resins without loss of adhesion or change of color.

Table 2—Electrical Properties at Various Frequencies

Frequency, cycles/sec	Dielectric Constant	Power Factor	Loss Factor
10^2	3.29	0.00149	0.0050
10^6	3.12	0.00432	0.0135
8.6×10^9	2.76	0.00520	0.0143

Table 3—Strength of Resins and Laminates

Type	Resin Properties			Laminate Properties	
	Heat Dist. Point, F	Tens Str, Psi	Elong at Break, %	Flex Str, Psi	Tens Str, Psi
Hetron 23 (rigid)	216	5000	1.9	62,000[1]	38,000[1]
Hetron 92 (rigid)	220	5900	2.4	58,000[1]	39,000[1]
Hetron X-31 (semi-rigid)	125	6200	7.6	38,000[2]	23,000[2]
Hetron X-32 (semi-rigid)	157	7200	3.3	35,900[3]	18,100[3]
Hetron X-32A (semi-rigid)	175	9300	4.3	32,400[3]	20,300[3]

NOTES:
[1] *42% resin, 58% OCF-181-136 glass cloth, ⅛ in. thick.*
[2] *45% resin, 15% filler, 40% glass mat (silane finish), 0.10 in. thick.*
[3] *45% resin, 15% filler, 40% OCF-T-99 glass mat, 0.10 in. thick.*

Table 4—Effect of Heat and Water Aging on Laminates

Resin	Flex Str, Psi	After 7 Days at 392 F			After Water Aging 1 Month
		Flex Str, Psi	Flex Str, % of Original	Wt Loss, %	Flex Str, % of Original
Hetron 23	61,900	34,500	55.7	2.37	84
Hetron 92	56,200	34,700	61.7	1.69	92
Fire Resistant Resin X	48,900	22,900	46.8	9.56	78
General Purpose Resin Y	60,500	25,500	42.1	4.23	84

NOTE:
Tests conducted on ⅛-in. laminates containing 40% resin, 60% 181-136 glass fabric by weight.

Table 5—Effects of Heat Aging on Cast Rigid Resins
(7 Days at 392 F)

Resin	Crushing Strength at Room Temp, % of Orignal	Weight Loss, %
Hetron 23	93	3.2
Hetron X-73	95*	5.0*
Standard Resin	45	9.7
Fire Resistant Resin A	55	8.2
Fire Resistant Resin B	27	18.7
Fire Resistant Resin C	0	14.6 (crumbled)

* *After one month.*

Applications

With the exception of their light aging characteristics, these resins appear to have service and fabrication properties equal and, in some respects, superior to the best polyester resins now available. At the present time, however, they cost 15-20% more than conventional resins. For this reason most applications for these new resins in the near future will be those in which fire-resistance is considered important enough to justify the added cost. Currently there are two large potential fields: building interiors and auto bodies. With reinforced plastics already popular in some areas as an outdoor architectural material, it is quite likely that the availability of polyester-glass laminates with sufficient fire-resistance to meet building code specifications would lead to broad usage of this material for architectural interiors. A still unsolved light aging problem will limit current exterior applications to those where yellowing is not a critical factor. If plastic auto bodies continue to be confined to sports cars, there may be little demand for a fire-resistant material. If, however, the use of plastic auto bodies becomes widespread, as some believe will happen, a fire-resistant material may eventually be considered necessary to public safety, low insurance rates and competitive position.

Fabrication

The new fire-resistant resins appear to be particularly well adapted to matched metal die molding. A rapid increase in fluidity on heating allows rapid and uniform flow of the resin to all parts of the mold. Excellent glass wetting, low shrinkage on cure and unusually good hot stiffness combine to give moldings with good surface finish that can be easily removed from complicated molds. These resins are also suitable for vacuum or pressure bag molding and hand lay-up fabrication. Depending on the catalyst system used, molding temperatures anywhere from room temperature to about 270 F can be used.

These resins show appreciably lower shrinkage on cure than conventional polyesters. In addition to improved surface finish, this makes possible somewhat better dimensional accuracy, fewer internal stresses and more crack-free moldings. Most

Service Properties

Density—Maximum density of rigid grades is about 0.0515 lb./cu. in. for the unfilled cast resin. Semi-rigid and flexible resins range from 0.0494 to 0.0476 for clear castings.

Light Aging—So far it has not been possible to stabilize these resins against yellowing on long and continuous exposure to light. In this fact lies the chief drawback of these resins compared with other polyesters. However, light aging does not affect strength and is not a problem in interior applications or where finishes are used.

Light Transmission—These resins have relatively high light transmission efficiency. For unfilled cast sheet 1/16 in. thick it is 91%. For unpigmented resin reinforced with glass mat, the light transmission of 1/16-in. sheet is 76% and that of ¼-in. sheet almost 50%.

Electrical Properties—Typical values for the dielectric constant, power factor and loss factor at various frequencies for these resins are given in Table 2. The loss factor is quite low over a wide range of frequencies and the dielectric constants are generally lower than those of conventional polyesters. Insulation resistance is also good. Arc resistance, however, is lower than for non-chlorine containing polyesters; it can be improved to some extent by fillers. Excellent electrical properties are maintained during prolonged exposure to high humidity and elevated temperatures.

Chemical Resistance—The cast resins have good resistance to acids, brine and water over a wide temperature range. They have unusually good resistance to 20% and 37% hydrocloric acid solutions up to boiling. They are not recommended for exposure to oxidizing acids, alkalies, some chlorinated solvents or the more effective oxygenated organic solvents such as acetone or ethyl acetate. Resin modifications in the direction of greater flexibility generally reduce chemical resistance.

Flexibility—Resins varying in elongation at break from 2 to 100% have been made with Het Acid. Good combinations of strength, stiffness and moisture resistance can be obtained in the semi-rigid (4-10% elongation) range.

Hardness—Surface hardness of the cast resins ranges from 30 to 60 Barcol, and the hardness of laminates from 50 to 80.

Strength—Typical strength values for these resins and laminates made from them are given in Table 3. Laminates made with the semi-rigid resins combine good tensile and flexural properties with high moduli and unusually good resistance to impact cracking.

Stiffness—Flexural and tensile moduli of these resins are unusually high for polyesters. A typical working value is 1.62 x 10^6 psi obtained for a 0.10-in. laminate containing 45% Hetron X-31, 15% filler and 40% glass mat with silane finish. Some of these resins have a top temperature limit above which stiffness falls off more rapidly than for conventional resins.

Water Absorption—The resins are uniformly low in water absorption and water vapor transmission. Water absorption for rigid resins appears to be about 30-50% of that for comparable conventional resins, and for semi-rigid resins only 20%. Castings of Hetron 23, tested at 23 F, absorbed 0.11% water in one day of immersion and had absorbed 0.50% after 14 days. Castings of Hetron 92 absorbed 0.15% in one day, 0.38% after 14 days and 0.55% after 30 days. A laminate made with Hetron X-31 absorbed about 0.07% in one day compared with 0.38% by a laminate made with a conventional semi-rigid resin. Moisture vapor transmission through these resins is claimed to be about 10% of that for conventional resins.

Wet Strength—In wet strength retention these resins are claimed to be equivalent to the best conventional resins. Retentions of 83-95% for laminates (OCF-181-136 glass fabric) wet aged one month are typical (see Table 4). This property depends greatly on the glass finish.

Heat Aging Effects—The high retention of strength and dimensions after heat aging of these resins is illustrated by the data in Tables 4 and 5.

Heat Distortion—Styrene cross-linked grades can be made with heat distortion points as high as 300 F. Higher values can be obtained with special cross linkers such as diallyl phthalate and triallyl cyanurate. Apparently there is no necessary relationship between the heat distortion point and the high temperature stiffness of these resins, nor can the high temperature stiffness of these resins be compared with that of other types on the basis of differences in heat distortion points (see Table 6).

High Temperature Strength—Elevated temperature crushing strengths of some typical grades are compared with that of a conventional resin in Table 6 This property can be varied over a wide range by adjusting the resin formulation.

grades have shrinkage values ranging between 4.5 and 6% although special resins have been made with shrinkage as low as 3%.

The resins have conventional curing characteristics and, with the proper catalysts and promoters, can be used with room temperature cures, high temperature cures and short mold cycles. Postcuring is usually not necessary.

Table 6—High Temperature Crushing Strength of Castings

Resin	Heat Distortion Point, F	Crushing Strength, Psi		
		212 F	248 F	285 F
Hetron 92	216	11,500	7,800	2,000
Hetron RN 9-3	226	10,700	8,300	6,000
Hetron RN 9-2	272	9,500	7,000	4,500
General Purpose Resin	200	3,200	0	0
Hetron LR 96A	187	8,500	—	—
Hetron LR 96B	190	7,000	—	—

by T. W. CURRY,
Lynchburg Foundry Co.

One Company's Experience with . . .

Shell Mold Castings

Pros and cons on 1) dimensional tolerances, 2) quality of finish, 3) reduction of machining, and 4) cleaning operations

Straight flat surfaces such as this are more difficult to produce because of shell warpage.

● SINCE SHELL MOLDING was announced in 1946 our company has been interested in the possibilities of the process and have studied it on a pilot basis. Based upon our findings and augmenting this by travel in the United States and abroad, visiting foundries, doing experimental and production work with the shell process, this article will discuss the pros and cons of the following: casting dimensions and uniformity of dimensions from casting to casting, finish, savings in machine operations, and cleaning shell-molded castings.

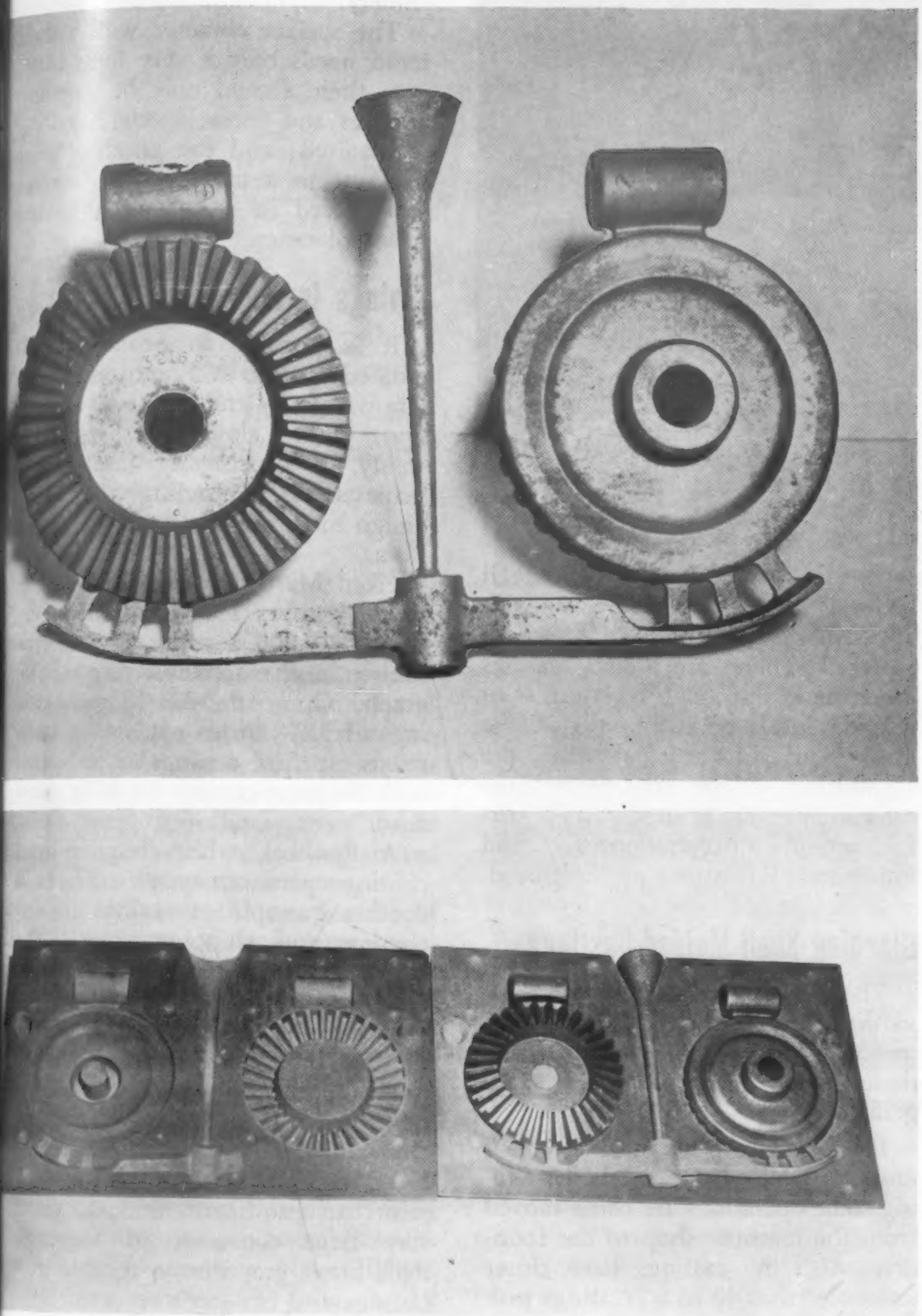
Casting Dimensions

There has been some misunderstanding as to the dimensional tolerances achieved by use of shell molding. We have found that you cannot quote a tolerance of 0.002 in. to 0.003 in. per in., for example, and expect it to apply to the dimensions of all castings which will be made by shell molding. Each casting must be studied with regard to its position in the mold and its particular characteristics before intelligently predicting the dimensions to be obtained.

Our experience to date with castings in a weight range of $\frac{1}{2}$ to 40 lb indicates that the following rules should be applied to shell-molded castings.

1. If all critical dimensions are in one side of the shell (all in the cope or all in the drag) drawing dimensions within a tolerance of ± 0.002 in. per in. can be obtained.

2. If the critical dimensions are across the joint of the shell mold, or if a core, which is made separately, is set in the mold, then the



A typical gear produced as a shell mold casting before cleaning. This gear met drawing dimensions with a tolerance of ± 0.002 in. At bottom is half shell mold used for casting.

dimension will be approximately 0.030 in. in excess of the pattern dimension. Some operators have reported as much as 0.060 in. in cases of this kind.

3. Certain types of castings, such as a wheel with a long, heavy hub, which are poured in the vertical position require a careful back-up procedure, or swells on the underside of the hub will be encountered.

4. There must be a means to get the metal into the mold, and if it is necessary to have a gate attached to a surface involved in a critical dimension, an allowance of a minimum of 0.020 to 0.030 in. should be made. Grinding fixtures will materially reduce this allowance, but attention is directed to this operation because some machining is now being done in the foundry.

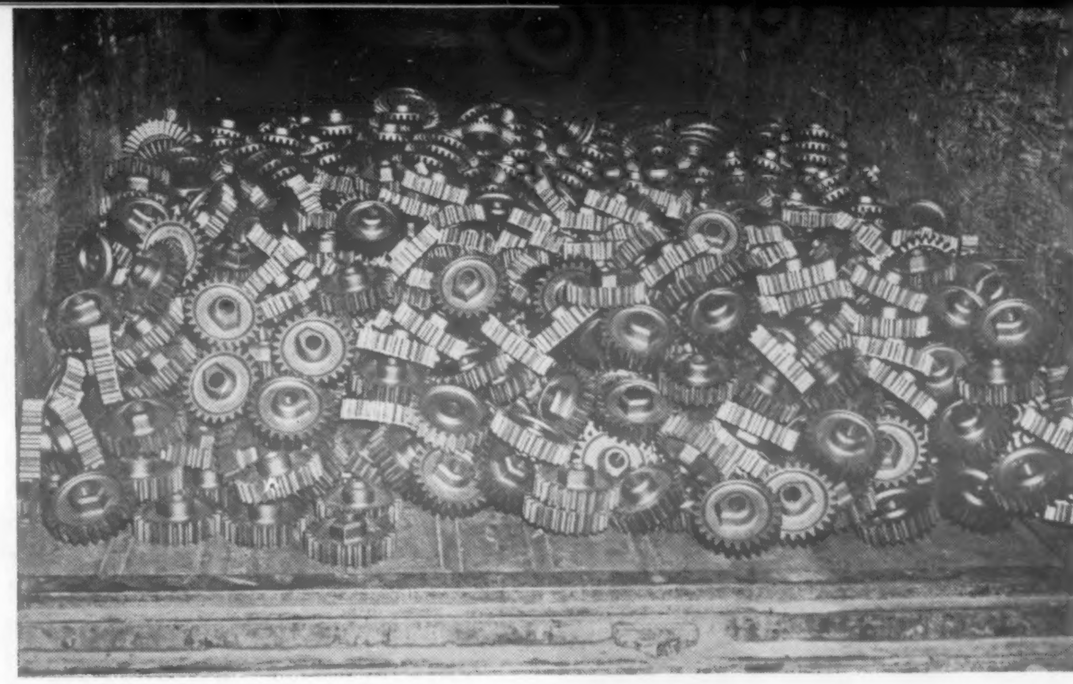
5. Out-of-roundness is encountered in some castings, when the critical dimensions are all in one side of the mold. It is particularly troublesome when the castings are poured in the vertical position. Indications are that some out-of-roundness might be caused by the use of a bottom gate and a riser at the top of the casting. There is a hot area on the vertical diameter caused by this method of gating and risering, and the casting does not have equal cooling rates in all directions.

6. Straight flat surfaces are difficult to produce. Shell warpage and shell-mold assembly contribute to this difficulty. There is a problem in stripping a straight shell from the pattern and both the mechanical and chemical engineers are working to improve this condition. The characteristics of the synthetic resin used as a binder can be changed materially to produce greater rigidity at the time of stripping and research is progressing in this direction. Some warpage can be corrected by proper use of the back-up medium and arrangement of the stripping pins. The most efficient way to reduce or eliminate warpage is to apply the same amount of heat during curing on the back of the shell as is applied on the pattern plate side.

The dimensions measured from casting to casting are uniformly within narrow tolerances. We have found that we may depend upon duplication of the gear casting shown in the accompanying photograph within 0.015 in. on the o.d. and within 0.005 in. on the i.d. of the hub. Dimensional uniformity of the casting is a valuable advantage in the machine shop.

Obviously, if good duplication dimensionally is obtained, then it is possible to obtain good duplication within the same tolerances on the drawing dimensions. We must gain experience with the process and statistically study dimensions of castings produced in order to properly alter the patterns, joints, and other steps in the process to produce castings within very close dimensional tolerances, found on duplication studies, of those on the drawing.

The dimensions discussed above may appear, in first judgment, to be quite a wide deviation from drawing and that green sand practice is a good or better one. However, in every case where we have replaced a casting molded in green sand with a shell-molded casting, the shell casting has been better dimensionally and more consistent in shape. Thus, before concluding that better dimensions and uniformity are not obtained by shell molding, we should statistically study the measurements of our green sand castings. It would



A total of 32,000 of these gears have been shell cast and have made possible a 52% saving in machining costs.

be well to keep in mind during this study that the ordinary small "pimple" encountered with a bonded #90 AFS fineness sand will stand from 0.015 in. to 0.020 in. above the desired surface.

Some castings seem to be "naturals" for shell molding while others present unforeseen problems and the latter group may prove not to be suitable for the process. Although there are exceptions, generally, as the size of the shell-mold to be poured increases, or the casting size increases, there is a need for greater tolerances on the specified dimensions of the casting.

Finish

The surface finish of shell molded castings is noticeably improved over any surface we have produced in green sand, or from a conventional core-sand washed with the coatings now available. The finish obtained is also consistent and is duplicated regularly in production.

Good finish is necessary because it plays a vital part in obtaining the dimensional tolerances cited. Also, a smooth surface has great sales appeal, which is listed by some large potential consumers as the number one advantage of the process. Both, however, go hand in hand and the combination of finish and consistent dimensions is much more valuable than finish alone in subsequent processing of the castings.

Shell molding is not an automatic means of producing a good surface finish. On the contrary, careful study is required, and the correct application of the sand-resin mixture to the pattern plate is one of the more difficult problems of the process to solve. Here again, some castings are "naturals" and almost all methods of investing the pattern with any sand mixture produce a smooth surface. There are other castings much more difficult to produce with a good finish because voids in the shell mold surface occur when the application of the sand is not exactly right. Voids in the shell surface produce a penetration effect, and finish and dimensions are destroyed.

Cleaning Shell Molded Castings

There have been many reports regarding the cleaning costs of shell-molded castings, some without foundation and others somewhat exaggerated.

In considering cleaning costs it must be realized that in shell molding some operations are being moved from the machine shop to the foundry. Also the castings have closer tolerances than those in castings produced in sand molds. Of necessity, the tools and methods for cleaning castings must undergo some drastic changes. In particular, special jigs and fixtures must be used.

Cleaning begins at the knockout stations and here it is necessary to avoid scarring the casting, remove the gates without breaking and palletize the castings for transfer to blasting room. The individual characteristics of the casting then determine whether a table or rotary blasting operation or some other type of cleaning equipment will be used. Ordinary shot mars the good finish already present and special blasting materials are necessary. A #90 AFS sand performs a very excellent cleaning job in the blast machine and there may be developments with other materials and cleaning machinery.

The surface obtained with a shell mold needs only a very light blasting; there should only be grinding at gates and risers; special handling is required; and the grinding must be done in a fixture if the surface is involved in a dimension having little tolerance.

Savings in Machining Operations

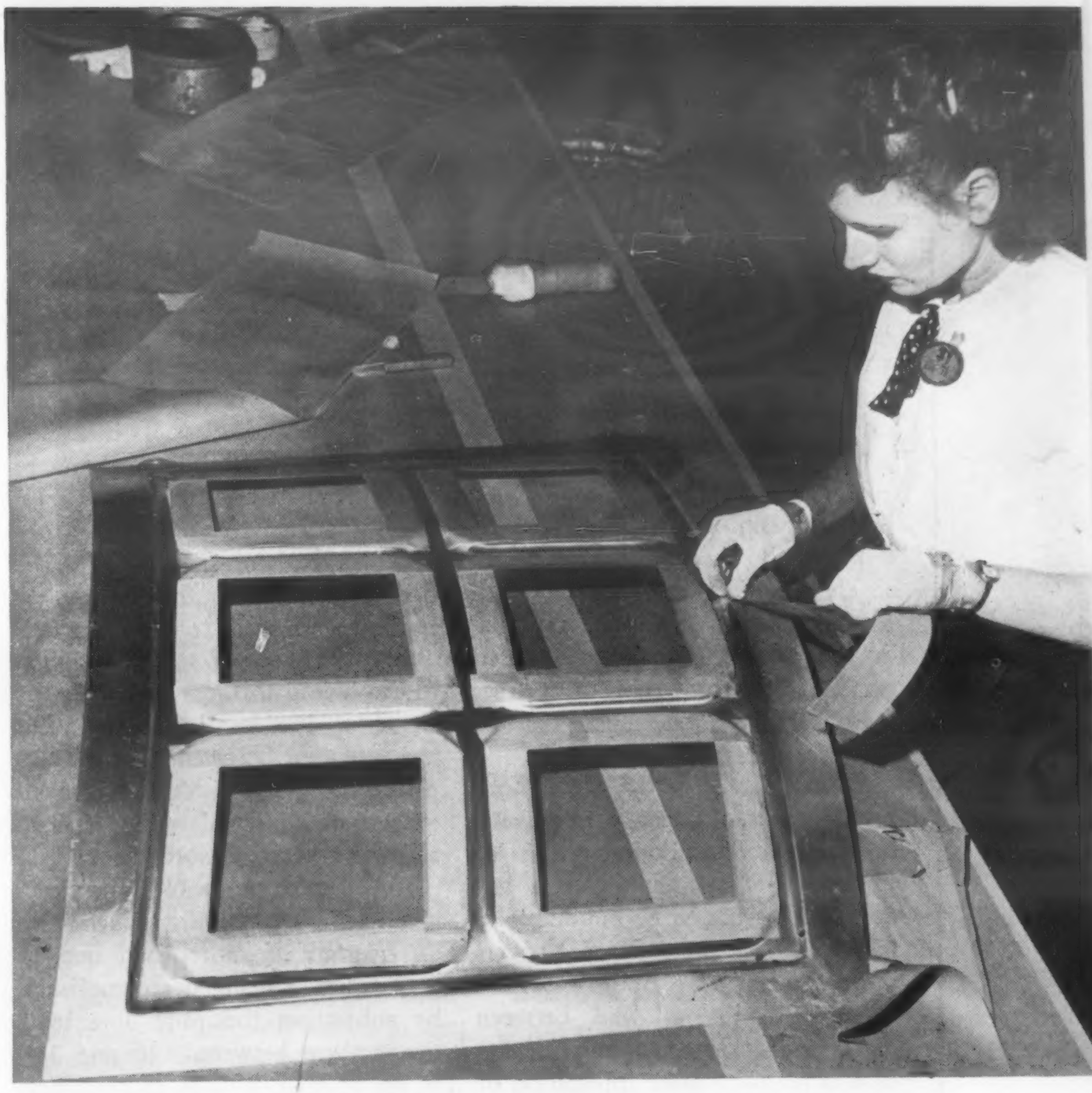
It is possible to produce shell-molded castings at a high production rate with excellent finish and dimensions within close tolerances. The ability to consistently duplicate a shape allows the tooling engineer to design methods to reduce machining costs.

From March 1953 to the present time (October 1953), we have delivered 32,000 castings of the type shown in the accompanying photograph. Our customer reports a savings of 52% in his machining operations on these castings as compared with the same castings made in green sand.

A flywheel, which requires machining operations on all surfaces is another example of savings in machining and shipping costs. The clean casting weight, made in green sand, was 80 lb, and it was possible to reduce the shell-molded casting to 60 lb. This is a great saving in shipping weight in addition to saving the expense of cutting 20 lb of metal from the casting. Twenty pounds of metal removed from an 80 lb casting seems an exorbitant amount, yet a very large consumer of forgings, steel, brass, gray iron, malleable iron castings and bar stock reported after a careful survey that 18% of the purchased weight of these commodities was removed in the machine shop. This may be in line with the thoughts of some machine shop operators when they express themselves by saying "when we cut we want to cut." There can be no other result than greater tool wear as the amount of metal to be removed is increased, and the tool cost per unit machined will increase.

In conclusion, shell molding is a process with a very high potential in quality, production and low final cost, and as knowledge of the process is gained, castings will further improve.

Adapted from a paper presented at the annual meeting of the Gray Iron Founder's Society, October 1953.



One adhesive used in the aircraft industry is provided in tape form. Here it is being applied to a cowl panel stiffener.

How Adhesives Are Used in Aircraft Construction

by D. A. TOOLEY, Consolidated Vultee Aircraft Corp., Ft. Worth Div.

Metal adhesives are making possible thinner aircraft skins, higher fatigue strengths, and savings in weight and space.

• THE USE OF metal adhesives is increasing, particularly in aircraft, as their advantages become better understood by designers. Thinner skins may be used in many applications with better smoothness than would be obtained with a comparable riveted structure. Fatigue resistance is increased in almost all cases because of the absence of stress concentrations at mechanical attachments. Space and weight savings may result in some designs, and there may be manufacturing advantages if parts and tools are designed to take full advantage of the process.

Magnesium alloys are now being adhesive bonded by several aircraft companies. Chance Vought is using bonded magnesium assemblies for some parts of their Navy fighter. Boeing is using such parts in Air Force bombers. Convair has been using bonded magnesium for several years on the B-36 bomber and the RB-36 reconnaissance airplane.

At present it does not appear that very much magnesium will be used on the higher speed supersonic airplanes, because, at the elevated temperatures developed by compression of the air, other materials have better strength-weight properties than available magnesium alloys for most applications. Therefore, most bonding of magnesium has been with adhesives developed for room temperature properties and having limited strength above 160 or 180 F. Little work has been done with the application of the newer high temperature resistant adhesives to magnesium alloys.

Adhesive Bonded Assemblies

Most of the bonded parts used by Convair are magnesium alloy assemblies. There are some cases where magnesium skin is bonded to aluminum alloy stiffeners and others where assemblies are all aluminum alloy. Phenolic laminates are used as spacers in some assemblies. Since there are estimated to be 9000 lb of magnesium in the B-36 airframe and most of this is used as thin sheet and extrusions, it is not surprising that most of the bonding applications are in magnesium. It is estimated that more than 5000 sq ft, some 25% of the exterior surface of the airplane,

This article was adapted from a paper presented at the Ninth Annual Magnesium Association Meeting, Nov., 1953.

How The Bonding Is Done

Proper cleaning and preparation of parts is the first and one of the most important steps in the bonding operation. Magnesium alloy parts to be bonded by Convair are first given the Convair anodic process known as "Manodize", followed immediately by a thin dip coat of zinc chromate primer. (Sheets are purchased with an oil coating because of the difficulty in removing a chrome pickle film.) Fingerprints and other soil are removed prior to application of cement by wiping all faying surfaces with a clean starch-free cheese cloth dampened with low flash naphtha. A low aromatic naphtha is used because the thin coat of primer previously applied must not be softened excessively.

After the naphtha has been given a few minutes to evaporate, one or two thin spray coats of M3C cement are applied as a primer to all areas to be bonded, and in many cases this thin coat covers the entire surface. At least 5 min. drying time is allowed between coats, and at least 20 min. drying time is required after application of the final coat.

After the sprayed cement has dried, stiffening member and doublers are placed in a locating tool. Metlbond tape is then applied to all faying surfaces. If the tape and the sprayed surfaces are too dry for the tape to adhere, it may be made tacky by moistening with toluene in small areas, or it may be covered with tape, the skin is applied in its proper location, after which parts are ready for curing.

The assemblies are placed in a curing fixture in such a manner that the locating tool described above is used to apply pressure to the stiffener flanges. The whole assembly is then covered with a rubber blanket, and spaces under the flat skin and under the blanket are partially evacuated to apply the necessary pressure. Pressures applied to the faying surfaces vary with the shape of the locating fixture, but any pressure between 10 and 100 psi is permissible. More consistent results are obtained with pressures above 25 psi. Pressures above 100 psi would be desirable for structurally important joints which have an overlap of more than one or two inches. Curing is accomplished by subjecting the joint line to a temperature between 320 and 350 F. for at least 30 min. If necessary, one or more additional curing operations do not damage the bond. However, when AZ31A alloy is used in the H temper, its properties will be reduced somewhat, and it is recommended that values below specification minimum properties be used for design.

Heat may be applied in an autoclave, oven, or special heated fixtures. The type of part used on the B-36 is such that it has been found economical to use large surface platen fixtures heated by circulating hot fluid. Pressure may be applied by any of numerous methods, but the use of a vacuum has been found to be convenient on many parts which are of such a shape that a bridging action in the fixture can multiply atmospheric pressure sufficiently for application to the faying surfaces. The use of metal or silicone rubber diaphragms containing positive air pressure is a convenient method of applying higher pressures, when required.

When the described method of pre-treating magnesium sheets is used, little additional corrosion protection is required. Parts are given an additional zinc chromate primer dip to coat all cracks and the interiors of closed sections, which have been supplied with adequate drain holes. This is ordinarily followed by a spray coat of zinc chromate primer on interior surfaces and by one or more finish coats on exterior surfaces.

are covered with magnesium skin which has its stiffeners attached with a metal adhesive. There are also comparatively small numbers of interior applications.

The adhesive used by Convair is known as Metlbond and was initially developed to the production stage by Convair. It is now manufactured by Narmco, Inc. This adhesive is provided in tape form with a nylon cloth carrier. A flexible metal adhesive, M3C, forms both surface layers of the tape. This establishes a bond to metal surfaces. The interior layer is a low pressure adhesive which is thermoplastic prior to cure. It is this material which permits comparatively low pressure bonding, because it equalizes pressures between imperfectly fitting parts or tools by flowing during the early stages of the curing operation.

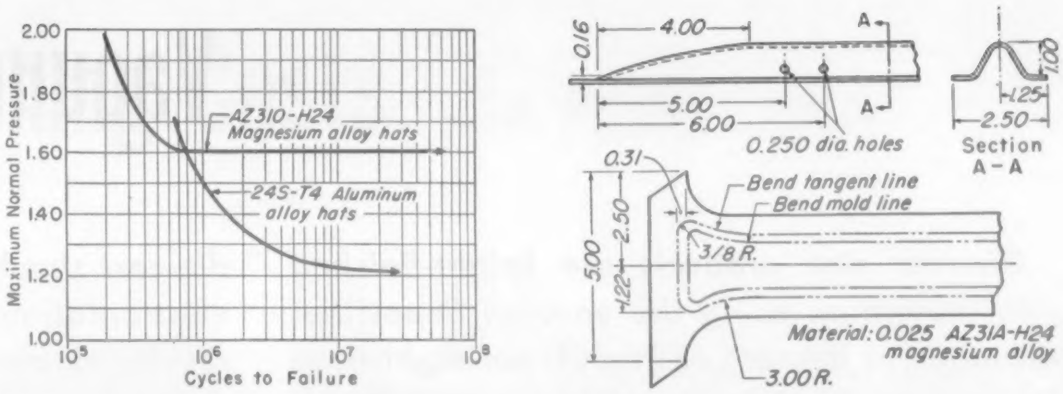
Initial extensive application of Metlbond on the B-36 was to join formed stiffener sections to thin magnesium alloy sheet, which was used as the exterior covering of the wing center section trailing edge. These stiffeners, known as waffle panels, are approximately 24 by 55 in., made from 0.025 in. AZ31A-0 skin. These assemblies, which were designed particularly for metal adhesive construction, proved to have excellent resistance to fatigue in an area subject to vibration because of its proximity to pusher propellers.

Satisfactory performance of this light weight structure has been responsible for the increased use of the adhesive on other assemblies, when their redesign was necessitated by some change in configuration or by previous unsatisfactory performance. Many such changes were made during the early years of the B-36 because of fatigue failures in conventional structures, caused by this vibration near the propellers, and because of other required design changes.

Other parts were, in most cases, of such a shape that it was not convenient to use the standard stiffeners described previously. Therefore, hat-section reinforcement were substituted. When these had open ends, cracks developed in the reinforcements after a large number of flight hours in locations of high vibration. A testing program was initiated in which approximately 240 stiffened panels of some 50 different designs were tested under conditions simulating flight vibrations. It was found that closed-end hat type reinforcements with the ends flared slightly to avoid a sudden change in section gave excellent results. It was nec-

essary to locate drain holes in areas of low stress and to avoid scratches during manufacture.

From this testing program it was learned that magnesium alloy stiffeners attached with a metal adhesive, when vibrated at low load which would not cause failure at a large number of cycles (such as one million) were superior to similar clad aluminum alloy hats of the same section, which weighed 50% more. See accompanying curves.



Magnesium alloy stiffeners attached to 0.010 or 0.025 in. magnesium skin with metal adhesive had better fatigue strength than similar clad aluminum type.

Shear Strength of Bonded Joints

The required minimum strength for adhesives to be used in production is 1250 psi in standard ½-in. overlap, 0.064-in. thick panels, which have been treated and bonded as described elsewhere in the article. Typical strength is 1600 psi or more. This process was developed to give good corrosion protection and adequate strength. The strength of magnesium alloy panels is somewhat more erratic than that of aluminum alloy, which is bonded bare, due to variations in the anodic treatment and the primer coat. It is interesting to note that, although strength in clad aluminum alloy is about twice as great as room temperature, there is little difference at 350 F and above, where the strength of both is in the 500 to 600 psi range.

Higher strength can be developed by the use of standard dichromate treatment before priming, instead of Manodize; but Convair believes that the corrosion protection afforded by the same weight of paint is inferior. Boeing is using the same metal adhesive as Convair to bond magnesium alloy. It is understood that they use a slight modification of the standard dichromate treatment and require a minimum strength well above 2000 psi in standard test panels. So far as is known, they have no corrosion difficulties.

Convair has made studies of several other treatments to determine whether higher strength and equivalent corrosion protection can be obtained. Magnesium sheets given the HAE treatment and others given Dow's new anodic treatment were tested. Some were primed before bonding and some were not. Average strengths obtained were less than with Convair's standard treatment, so that it did not appear worthwhile to continue the study in hopes of any improvement.

The best strengths obtained were on bare magnesium alloy which had been cleaned by wiping with a solvent, then acid cleaned in a solution containing chromic acid and calcium nitrate, a treatment similar to Dow's "acid pickle." Strengths obtained, from 2500 to 3000 psi, were a little inferior to those obtained with clad aluminum alloy. However, corrosion protection would offer some problem. Joints bonded to bare magnesium and given the Manodize treatment followed by zinc chromate primer dip lost strength, probably due to chemical action, and resistance to salt spray was poor. Coating of the bonded untreated panels with a primer activated with phosphoric acid gave good salt spray protection without affecting joint strength. Most such primers are not stable in the dip tank, so that coating interiors of hollow sections might be difficult. However, there is now at least one such primer which is reported to have adequate dip tank stability. The use of this type of primer on untreated magnesium requires some study, because small blisters may be formed, probably by an excess of phosphoric acid.

Metlbond joints have given satisfactory performance on the B-36. A few assemblies have failed in fatigue, but the cracks appear to have started at stress concentrations caused by rivets or screws, or as a result of walking loads on thin skins, which caused excessive permanent deformation. There has been no corrosion reported in Metlbond joints. The spray coat of M3C cement adjacent to joints appears to add to corrosion resistance. Corrosion reported on such assemblies has been limited to areas where water condensed and formed drops on the lower surfaces of flat sheet, on airplanes which have been subjected to a tropical salt atmosphere.

Other Metal Adhesives

The metal adhesive used with magnesium alloy by Chance Vought is Redux, a material developed in England. In joints with small overlap, this has considerably more strength than Metlbond. Since it is primarily a resin base material, whereas Metlbond contains synthetic rubber, it has a much higher shear modulus.

The practice followed by Chance Vought is to clean the oiled magnesium sheet in a manner similar to the acid pickle described for Metlbond, followed by dipping in a crome sulfate solution. Bonding is ordinarily accomplished in an autoclave at a pressure of 90 psi, with a curing cycle of 290 F for 30 min. Bonded assemblies are given the dichromate treatment and painted.

Strength developed in one inch overlap joints in 0.064 in. thick magnesium alloy sheet is higher than values quoted above for Metlbond. The production minimum is 1400 psi, and average values are from 1800 to 2000 psi. Redux appears to be more difficult to apply than an adhesive in tape form such as Metlbond, and required bonding pressures are higher. However, the application of the liquid adhesive and powder in the Chance Vought plant has been simplified to the point where it appears to be quite practical.

As far as is known, no other metal adhesives are being used for magnesium alloy production parts. Convair has tried the polyvinyl acetate-phenolic resin type sold as FM-47 and Plycozite. Results with conventional methods of magnesium alloy treatment are erratic and unsatisfactory. No attempt was made to develop a treatment which might give better results.

Metlbond 402 tape, a new material developed for high temperature resistance, appears to give results similar to coventional Metlbond when used over primed magnesium, but results on bare metal are unsatisfactory.

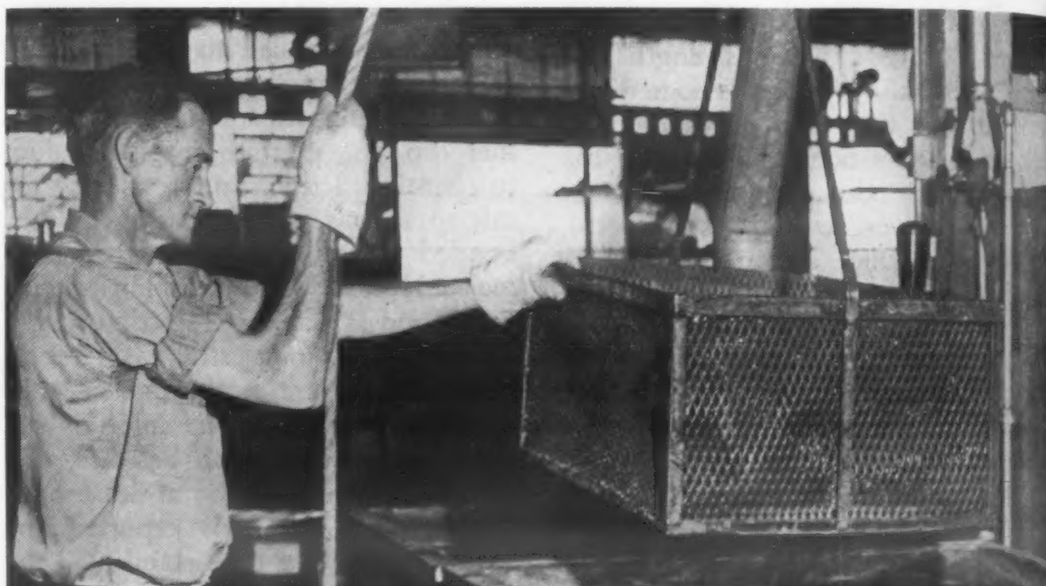
Vacuum Metallizing

Die-cast zinc products are bright-finished with aluminum using the vacuum deposition technique at the rate of 20,000 per eight-hour day in a single 48-in. metallizing unit at Yoder Manufacturing Co. The finish withstands 250 hr of salt spray without breakdown and costs one-sixth that of electroplating. The savings are traceable largely to the fact that the parts now need no buffing or polishing.

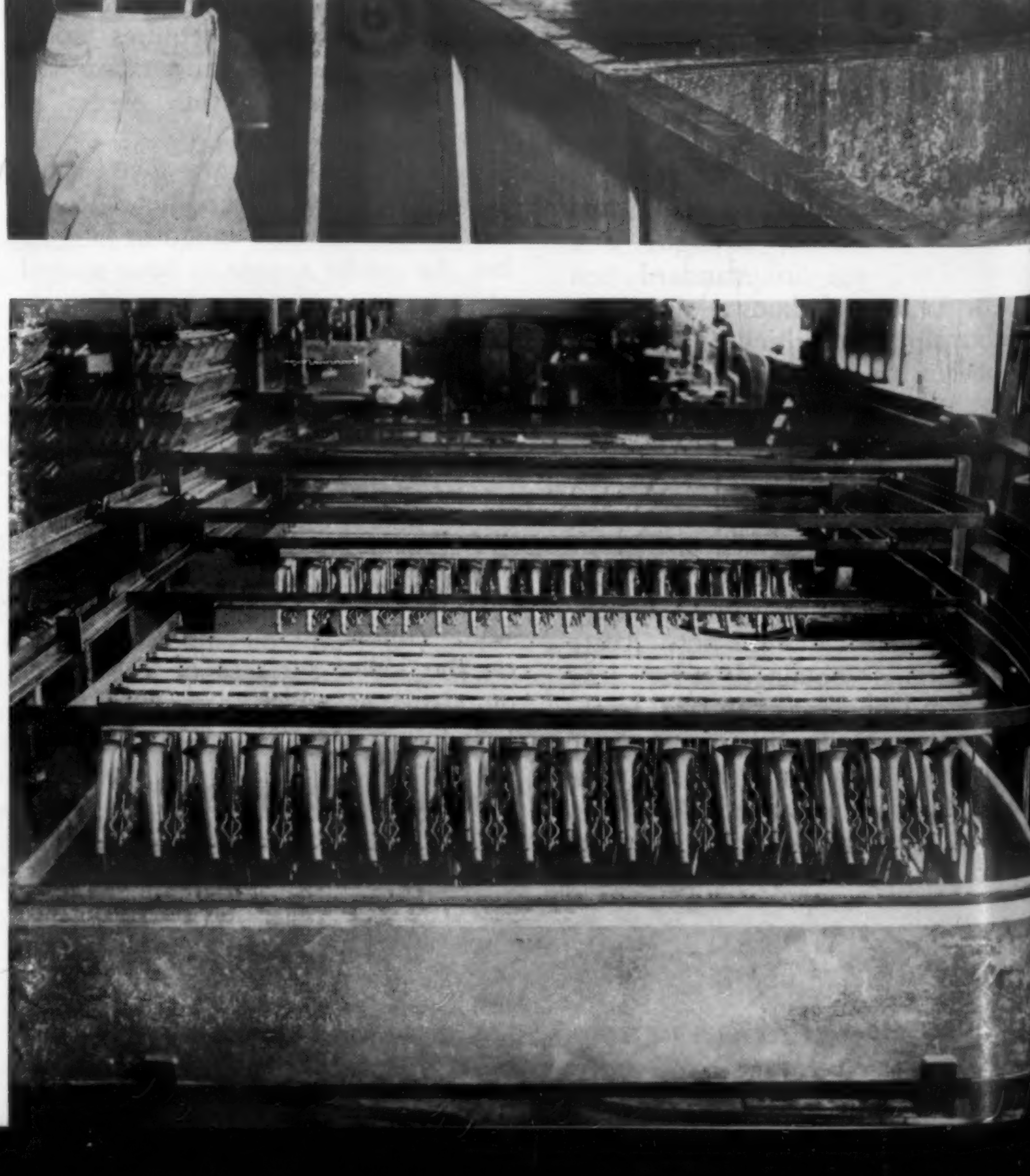
Until converting to vacuum metallizing, the die-cast zinc horns were finished by chromium electroplating. Besides the saving, the end-results obtained by vacuum plating are also noteworthy. The die-cast zinc horns have a higher luster and greater eye-appeal than obtained with chromium plating.

The complete finishing procedure, involving de-greasing, a phosphate dip, lacquering, metallizing, and a second lacquering to protect the finish are shown in these photographs.

1 DE-GREASING AND PHOSPHATE COATINGS are first steps in finishing the zinc die-cast horns. The light phosphate coating, while not absolutely essential provides extra rust-protection but, more important, produces a roughening of the surface of the zinc which promotes a better bond between it and the coat of lacquer which is applied next.

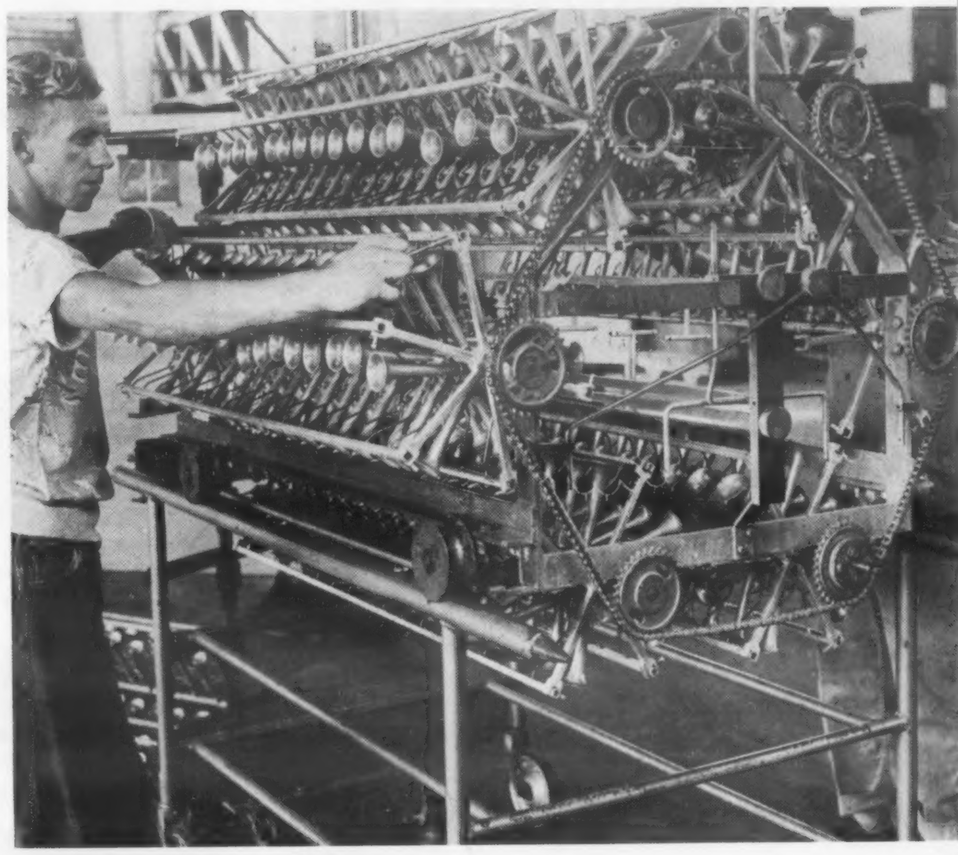


2 LACQUERING is one of the key steps largely responsible for the smooth, brilliant, appealing finish of the final product. Lacquer dip tank is raised by a hydraulic jack until the lacquer completely covers the horns, then is lowered very very slowly so that the coating of lacquer is perfectly uniform and free of runs. This smooth, slick undercoating is exactly duplicated by the metallized coating.



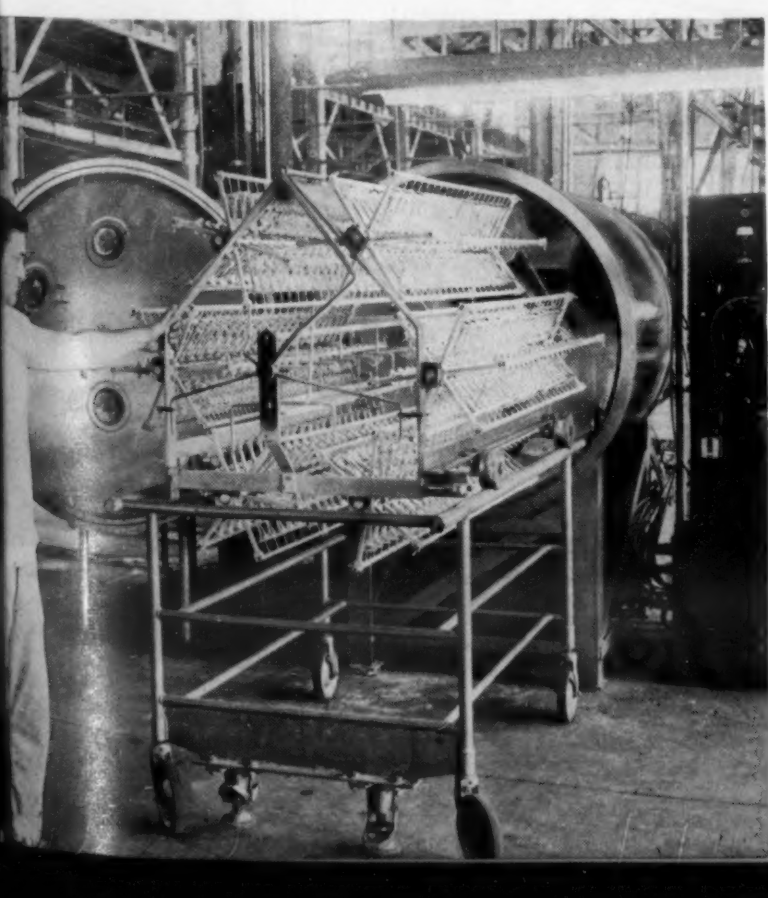
Reduces Finishing Costs —A PICTORIAL STORY

3 BAKING of lacquered horns in ovens takes 35 min. The lacquer coating closes the pores of the zinc die-casting and seals in the plasticizer of the acetate plastic, thus speeds up the pump-down of the chamber by preventing out-gassing from the horns. This quickens the vacuum processing cycle as well as contributes to a smooth surface.



4 LOADING lacquered horns onto the "spiders" of metallizing unit. The chain drive rotates these spiders during the flashing period when the aluminum is being vaporized so that all parts of the horns are brought into the line of fire and are coated.

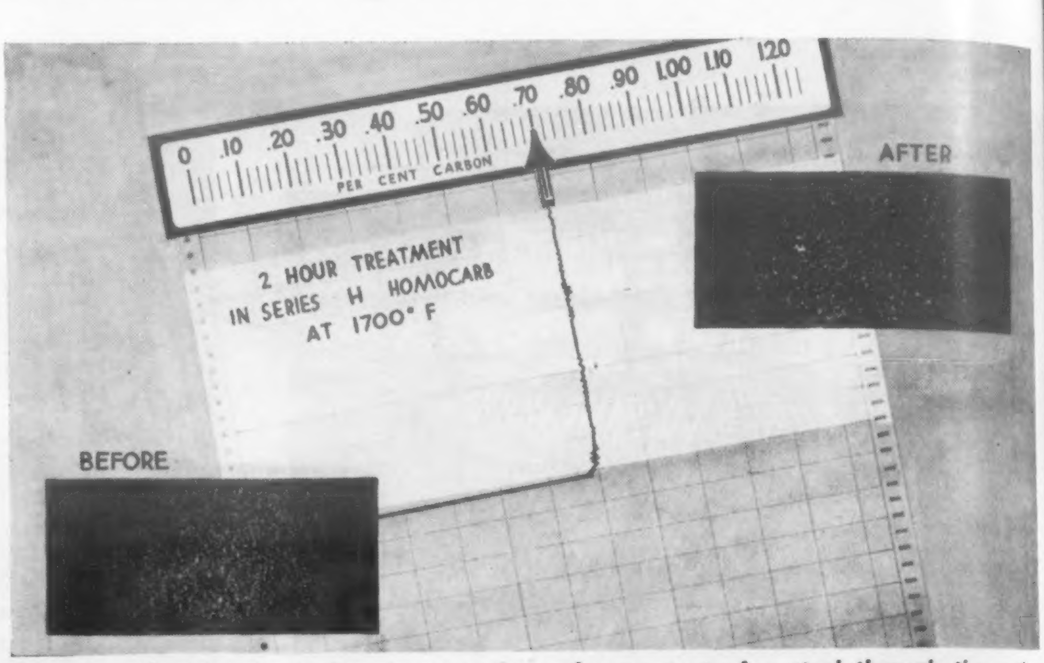
5 METALLIZING operation is accomplished in a Stokes 48-in. metallizing unit which takes up only 150 sq ft of floor space, including the vacuum pumping system. This single unit metallizes 20,000 horns per eight-hour day.



6 SECOND LACQUERING of horns is done like first. Horns are then baked for 35 min. The hard, tough coating protects the brilliant and lustrous metallic finish. If desired, the lacquer over-coat can be dyed to give a gold color or simulate any other metallic hue.

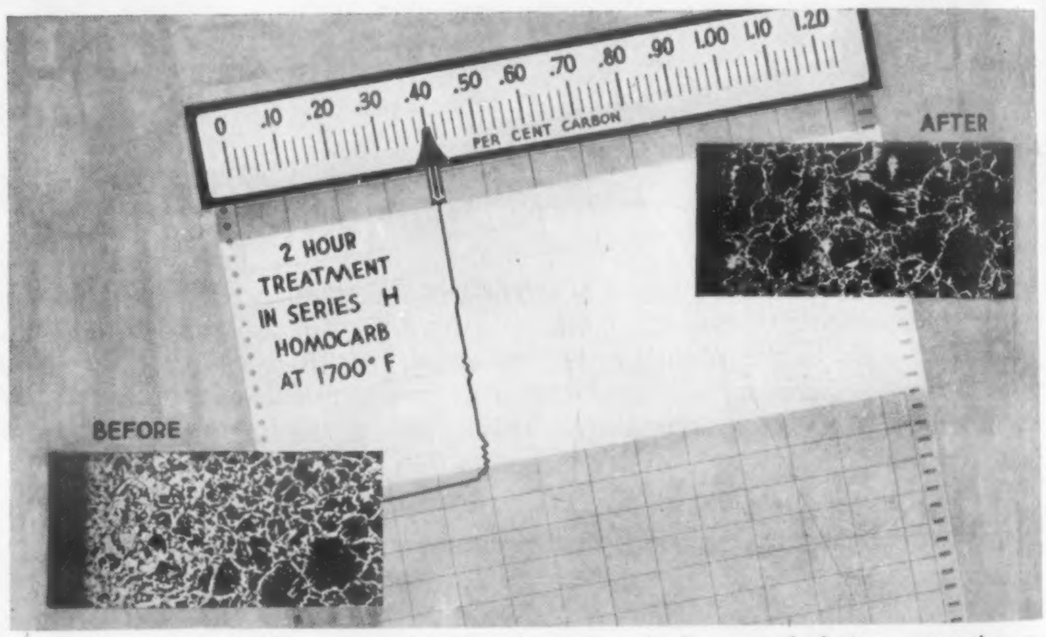
Now—Carbon Controller Makes Possible Accurate

Carburizing



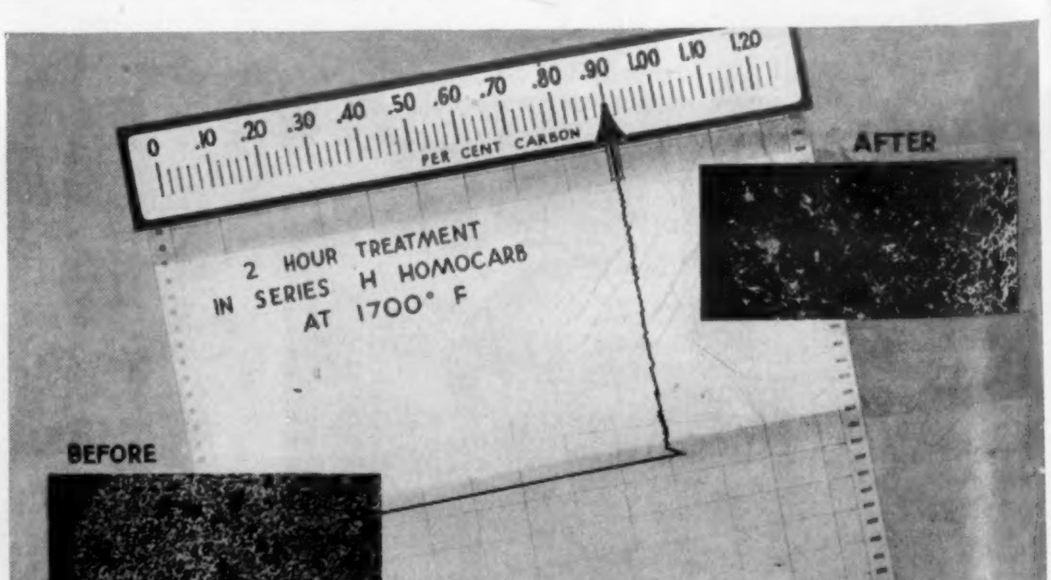
Through carburizing is used to increase the carbon content of a steel through the entire cross-section.

Carbon Restoration



Section of C-1137 tubing in which decarburization had occurred during processing, recarburized to the original value by carbon restoration.

Homogeneous Carburizing



SAE 1315 cam stock carburized with surface carbon controlled to 0.90 by a 2 hr treatment at 1700 F.

by **WAYNE L. BESSELMAN, Leeds & Northrup Co.**

● THE HEAT TREATMENT of steel is frequently accomplished with the steel surrounded by a carbon bearing gaseous atmosphere. At the elevated temperatures normally used, steel is sensitive to the active carbon in the atmosphere surrounding it. The effect of this active carbon is dependent not only on the composition of the gas but also on surrounding conditions, such as temperature, condition and area of work surface, furnace condition, catalytic agents and contaminants. Measurement of active carbon in the heat treating atmosphere is, therefore, much more involved than the mere determination of the composition of the gas.

In treatments such as hardening, the atmosphere surrounding the work should be protective and of a carbon potential which equals that of the steel, so that carbon is neither added to nor removed from the steel. In processes where carbon is to be added to the steel, such as carburizing or carbon restoration, it is often necessary to hold the surface carbon to a definite value.

Carbon potentials can be predicted from the measurement of certain components in the atmosphere such as carbon dioxide, methane, or dew point, if a state of equilibrium exists. In commercial practice, however, equilibrium conditions rarely exists because of factors such as flow of carbon from or into the work, air infiltration into the furnace, catalytic effects and variations in the atmosphere supply. It has been found that correlations of gas composition measurement with carbon potential are difficult due to such variations.

Investigation of various methods of measurement and control of carbon potential, indicated that the solution lay in the development of a primary element which would respond directly to these variables in precisely the same manner as the work in process. This primary element would measure the carbon potential of the atmosphere in the same manner as a thermocouple measures the temperature.

Such a primary element has been developed. There has also been developed a method of self-calibration which is a practical necessity since there is no other measuring device available for comparison purposes.

Primary Element

Functioning of the primary element, called a Carbohm, depends on exposing an iron-alloy wire to the atmosphere being measured. The wire is sufficiently fine to reach equilibrium with the surrounding gas rapidly. As carbon flows into or out of this wire at a fixed temperature, the electrical resistance changes in accordance with the curves shown.

The iron-alloy wire, supported in a ceramic insulator, is mounted in a protecting tube which is inserted through the lid of the furnace. Furnace atmosphere is drawn into the tube and over the detector which senses any change in the carbon content of the atmosphere in a few seconds.

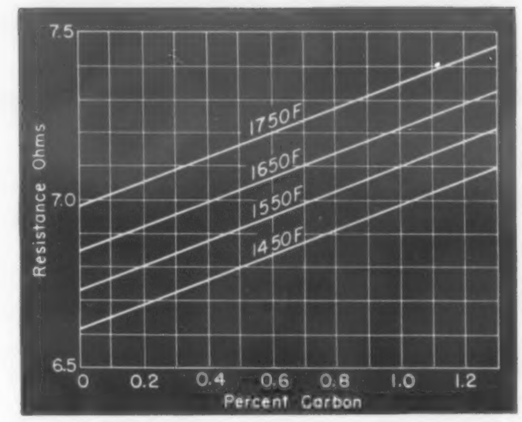
Furnace and Instruments

The Homocarb furnace can be either a pit-type or a horizontal type. In either case ribbon type electric heaters provide the heat source and a high speed fan circulates the atmosphere through the load. The carbon controller is an electronic instrument which measures the resistance change in the Carbohm and automatically regulates the flow of carburizing fluid to maintain the furnace atmosphere at the desired carbon potential. To assure accuracy, resistance changes caused by temperature variations are compensated for automatically. A continuous record of the percent of active carbon in the atmosphere is drawn by the carbon recorder.

Operation of the equipment is simple and well adapted to continued service in production plants. The system is effective over a range from 0.15 to 1.15% carbon and a temperature range of 1450 F to 1750 F. Overall accuracy of measurement and control is $\pm 0.05\%$ carbon which is sufficiently accurate for any present day requirements.

Case Carburizing

Controlling surface carbon concentration is necessary on many carburized parts fabricated from carburizing steels. On highly stressed parts, such as those used in the aircraft industry, which are usually slow cooled and reheated for hardening, it is



Relation between electrical conductivity and carbon content of steels.

necessary to control carbon concentration to prevent retention of a network of excess carbides after the final hardening treatment. A continuous network is objectionable because the hard carbides exposed at the surface tend to pit in service, setting up stress raisers which finally develop into cracks and, ultimately, fatigue failures. In addition, a continuous carbide network is often responsible for grinding cracks on precision gears and parts during final grinding operations after heat treatment.

During recent years there has been a decided trend towards direct quenching many of the alloy carburizing steels in the automotive and machinery industries because of the economy of a single heat treating operation and the fact that distortion is kept to a minimum. However, to produce satisfactory hardness on direct quenching, it is necessary to control carbon concentration in the case. High carbon concentrations produce structures with large amounts of retained austenite which are too soft for most applications.

Practically all highly stressed parts made of the alloy carburizing steels are superior metallurgically if the surface carbon is held within specific limits. For most applications a range of 0.80 to 0.95% carbon appears to be satisfactory.

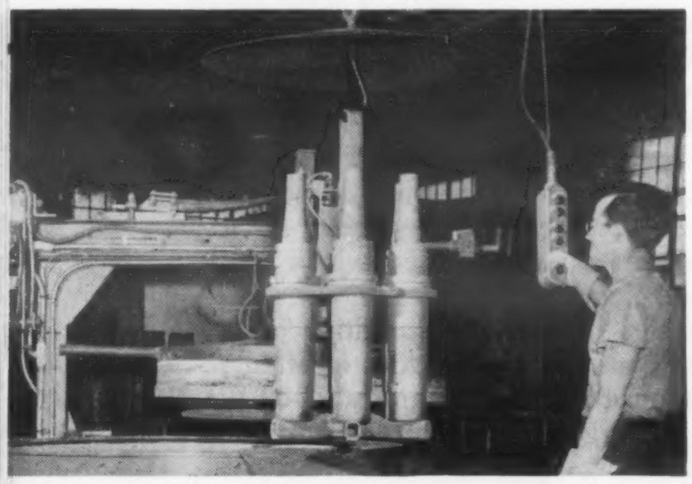
Hardening

Most structural steels and many tool steels are susceptible to carbon pick-up because of their medium carbon content and/or the carbide forming nature of such elements as

chromium and manganese. With carbon control it is possible to harden such steels with no gain or loss of carbon during the hardening heat.

Structural alloy steels requiring close control of the carbon potential are SAE 4340 or similar medium carbon steels. Such steels would be used for wing struts, propeller shafts and components for aircraft landing gears.

Tool steels requiring atmosphere control which might be used for production parts are: the non-deforming steels which are either oil or air hardened and contain manganese or chromium, and the shock resisting steels with medium carbon content containing chromium, molybdenum and manganese. A typical example is the hardening of bearing races of SAE 52100.



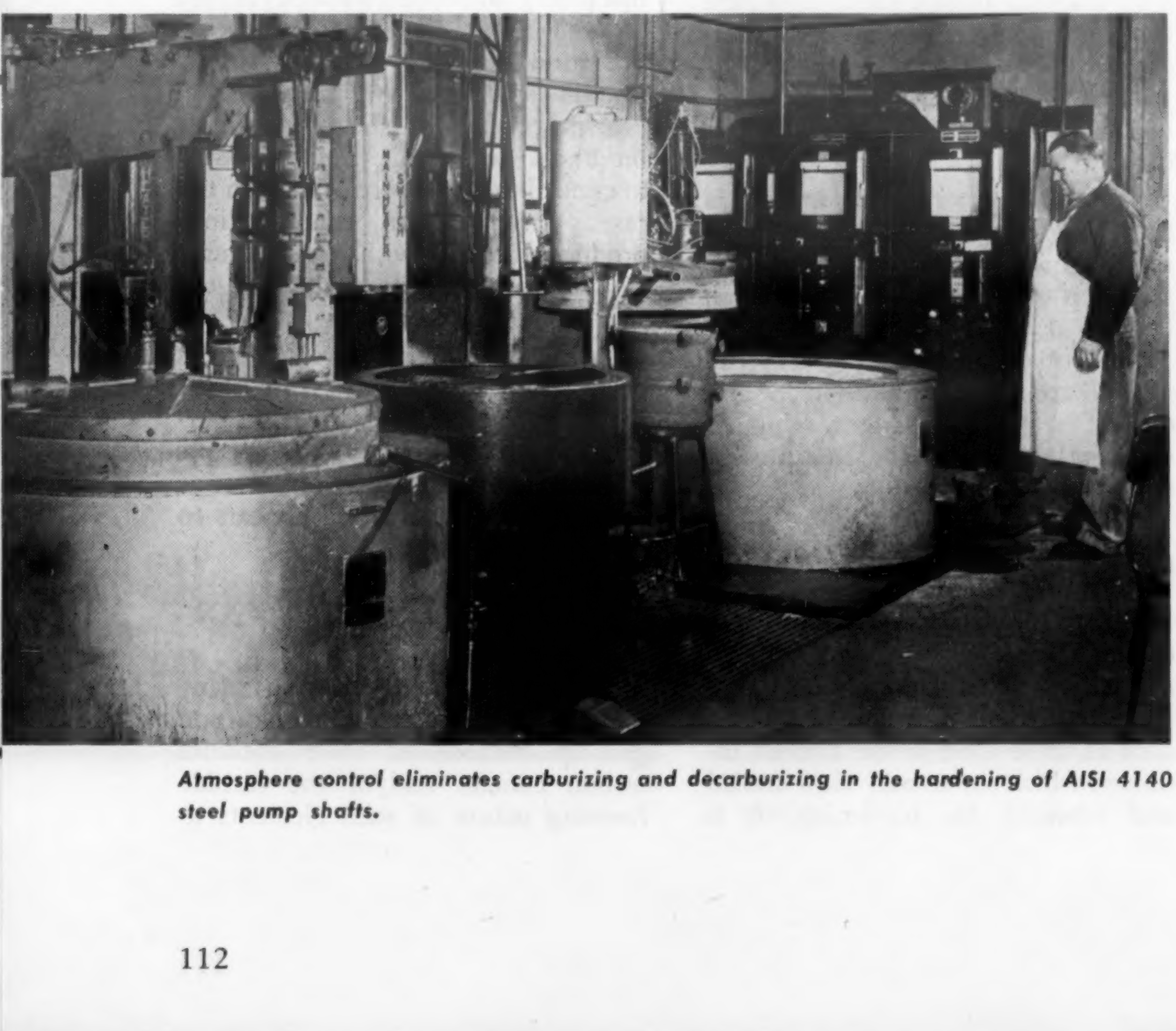
Aircraft propeller shafts of AMS 6415 steel are hardened in a furnace with carbon control to minimize distortion and meet specifications.

Carbon Restoration

Carbon restoration is the replacing of carbon in decarburized surface layers of steel until the carbon content of the surface is the same as the core. The decarburized layer may be the result of various processing treatments by the supplier or of a heat treatment during fabrication by the user.

With the exception of cold or hot rolled stock which is centerless or flat ground after annealing by the supplier, practically all steel received from the mill has varying amounts of decarburization. For example, the bolt industry used cold drawn wire and fabricates a large percentage of this wire into bolts by cold heading and rolling the threads. Where bolts are heat treated to meet specified mechanical properties the layer of decarburization must be restored to meet these requirements. One large bolt manufacturer states that the decarburization on the wire which is used for heat treated bolts ranges from 0.005 in. to 0.030 in., the largest percentage falling between 0.005 and 0.015 in.

Brazing operations frequently produce objectionable decarburization on parts fabricated from medium or high carbon steels. A typical example of carbon restoration is a rifle bolt with an SAE 4640 head and a C. 1137 body joined by brazing at 2050 F. Micro-examination shows that decarburization of 0.020 in. on the head and 0.040 in. on the body can be expected after brazing. Obviously such a condition must be corrected before proper hardness can be obtained.



Atmosphere control eliminates carburizing and decarburizing in the hardening of AISI 4140 steel pump shafts.

Homogeneous Carburizing

Homogenous carburizing is the through-carburizing of work of light cross-section so that carbon concentration at the center is approximately the same as that at the surface. For example, a thin cold formed part which is fabricated from SAE 1010 and then homogeneously carburized at 0.70% carbon will have, after heat treatment, about the same physical properties as if it had been fabricated from SAE 1070.

Homogeneous carburizing can generally be applied to deep drawn parts and stampings which are cold formed into difficult and intricate shapes where low carbon material must be used so that cold working operations can be performed satisfactorily, but where the final part must be of a higher carbon to meet physical requirements. It is a relatively new heat treating process whose possibilities have not been fully explored because a satisfactory method did not exist previously. Applications should develop when tool engineers begin to realize the cost-cutting possibilities compared to machining from solid stock of higher carbon content and heat treating.

At present there should be applications for homogeneous carburizing in any plant making light weight mechanisms, such as typewriters, business machines, etc. or in plants fabricating fasteners, such as spring clips, lock washers, etc. A typical part illustrating the use of cold forming and homogeneous carburizing is the carrier in a rifle mechanism. Previously this part was machined from ¾-in. square bar stock of SAE 1070 and then heat treated. Now the part is stamped from 0.052-in. sheet, cold formed and homogeneously carburized. Obviously, the savings in material and fabrication costs will be quite large.

Acknowledgment

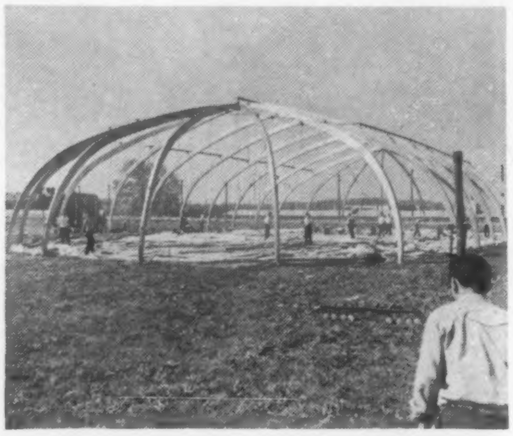
The writer is indebted to Leeds and Northrup Co. for permission to publish this paper and to his colleagues R. L. Davis II, and F. L. Spangler for their helpful assistance in its preparation.

Materials at Work

Here is materials engineering in action . . .

New materials in their intended uses . . .

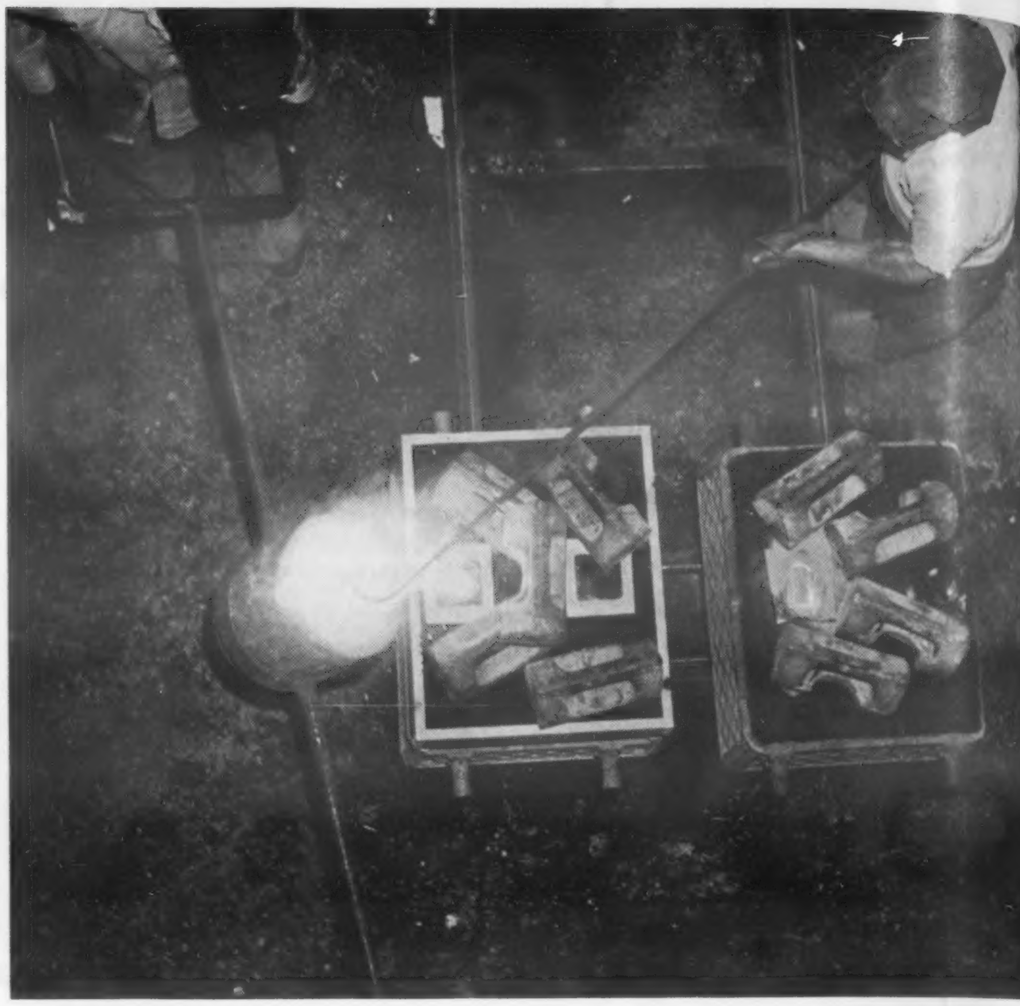
Older, basic materials in new applications . . .



Aluminum Big Top Shown here in various stages of completion is the "Aerodome" tent used by General Motors in their "Parade of Progress" exhibition now touring the country.

The aluminum framework supporting the tent is made up of 56 pieces of metal, plus 28 arched girders and 28 tubular connecting links. The aluminum-pigmented plastic-impregnated canvas covering is suspended from the underside of the framework by a network of ropes and pulleys. The treated canvas is fire resistant and water and light proof.

The structure, 152 ft long, 80 ft wide and 26 ft high, is free of poles or other obstructions inside, and there are no guy wires or stakes outside. It seats 1250 people.



Cellophane Keeps Stainless Steel Pure

Cellophane sheets are used by technicians at The Cooper Alloy Foundry Co. to keep dirt and impurities from entering sand molds prior to pouring stainless steel castings.

The squares of cellophane are glued to light cardboard frames and placed over the open heads as soon as the molds are closed. They are fastened, either with toothpicks for the smaller, or staples for the larger, on two corners of the mold to allow continual ventilation and avoid moisture condensation.

The covers are then brushed clean and the molten stainless is poured through the transparent cellophane.

Rubber Ensures Hydraulic Suction in Cutlass

This rubber pendulum (insert) made of B. F. Goodrich's Hycar American rubber serves as the suction line in the hydraulic reservoirs of Chance Vought's new jet fighter, the F7U-3 Cutlass. Molded for this use by Immel Engineering and Development Co., the material is resistant to the deteriorating effects of hydraulic fluid that cause ordinary rubbers to swell and lose flexibility, and also retains its properties through the range of temperatures experienced during high speed, high altitude flight.

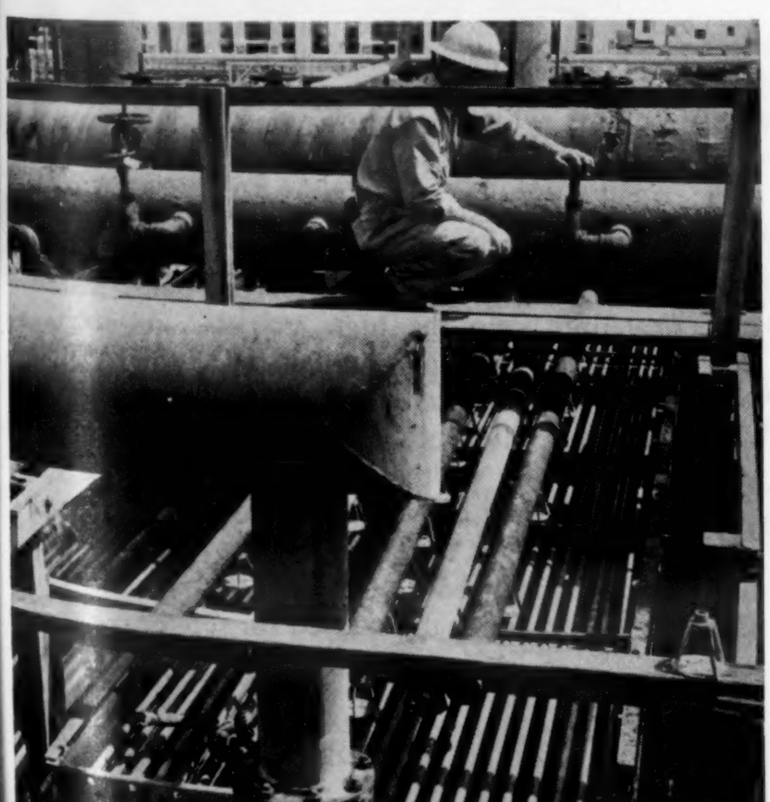
The pendulum is designed and weighted so that it remains in the fluid regardless of the position or attitude of the aircraft. The Hycar forms a permanent bond to the metal weights molded into the pendulum so that suction is maintained constantly, eliminating the danger of air entering the system.

Magnesium Aids Pickaback Freighting The magnesium ramp shown above, manufactured by the Magnesium Co. of America, is said to add speed and flexibility to the railroad practice of end loading truck trailers on to flatcars.

The ramp is 45 ft long; 9 ft wide, flaring to 11 ft at ground level for easy approaches; and weighs 4800 lb. It is raised or lowered by a hydraulic jack and, when detached, moves on rubber tired wheels. Nine inch high curbs prevent runoff and excessive tire wear.

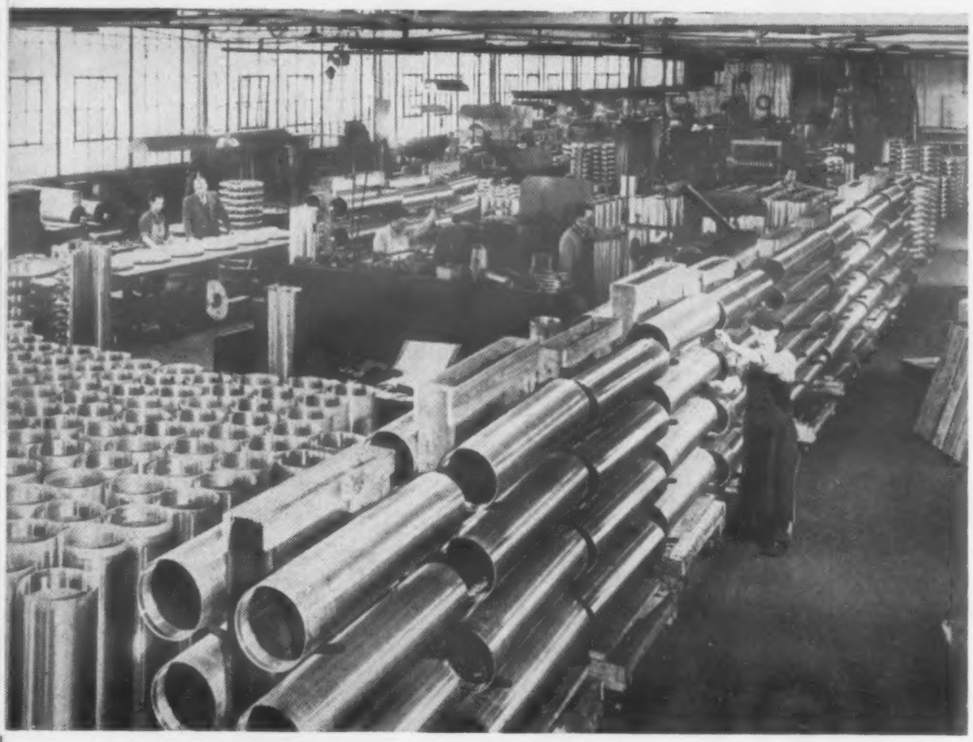
Arsenical Admiralty Clad Stainless Resists Stress Corrosion Difficulty has been encountered in atmospheric coolers such as that of the Celanese Corp. shown here, when stress corrosion of plain stainless steel piping became apparent on the outside of the pipes. This was caused by small amounts of chlorides in the fresh water spray used to cool the pipes.

The problem was eliminated by revising the piping installation to utilize Bridgeport Brass Co.'s Duplex Tubing with arsenical Admiralty on the water side and stainless steel on the inside, since the latter satisfactorily resists the acetic and formic acids carried. In addition, the heat transfer properties are said to have been improved.



Titanium Locknuts Weigh Less Than Half the Weight of Steel Titanium locknuts, now in commercial production at Elastic Stop Nut Corp., meet AN tensile strength requirements for steel nuts of the same thread size, but weigh less than half as much as steel hex nuts.

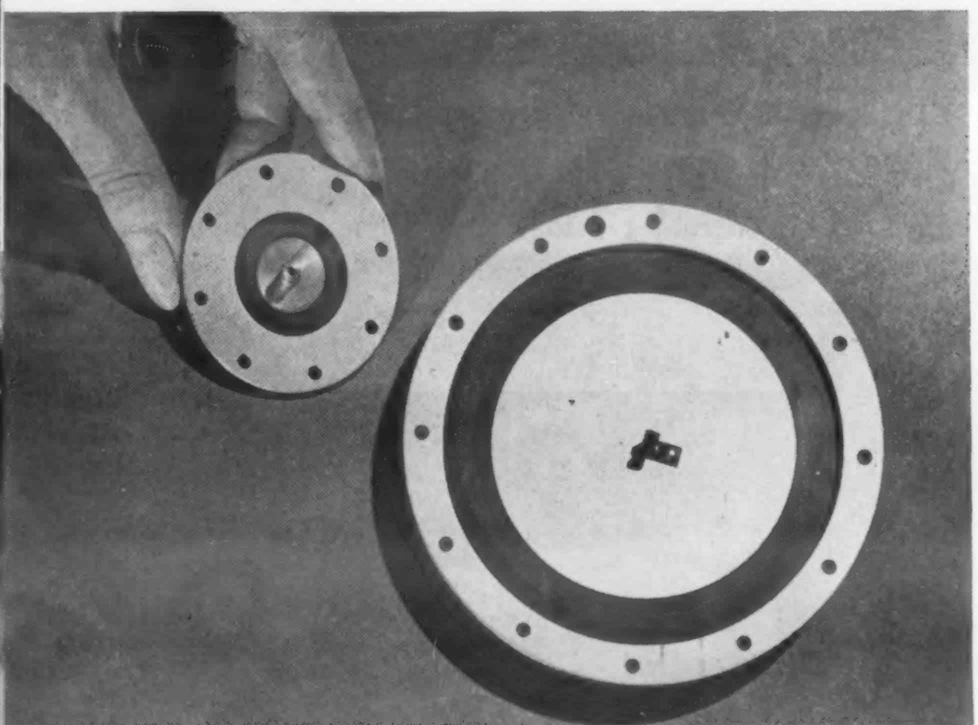
First production is of 12-point double hex nuts with nylon locking collars, in sizes from 5/16 to 5/8 in. Other types will be added to the line at a later date, the company says.



Aluminum in the Textile Industry

The light weight characteristic of aluminum is bringing this metal into wider and wider use in the textile industry as well as elsewhere. Here the Hayes Industries, Inc., are fabricating loom beams from aluminum tubing and cast aluminum heads.

The high speeds and sudden reversal characteristics of certain loom parts make weight reduction particularly desirable. Aluminum lay beams and hand rails are replacing steel-reinforced wooden lays and rails. Aluminum extrusions are also being used to advantage in loom lay beams.

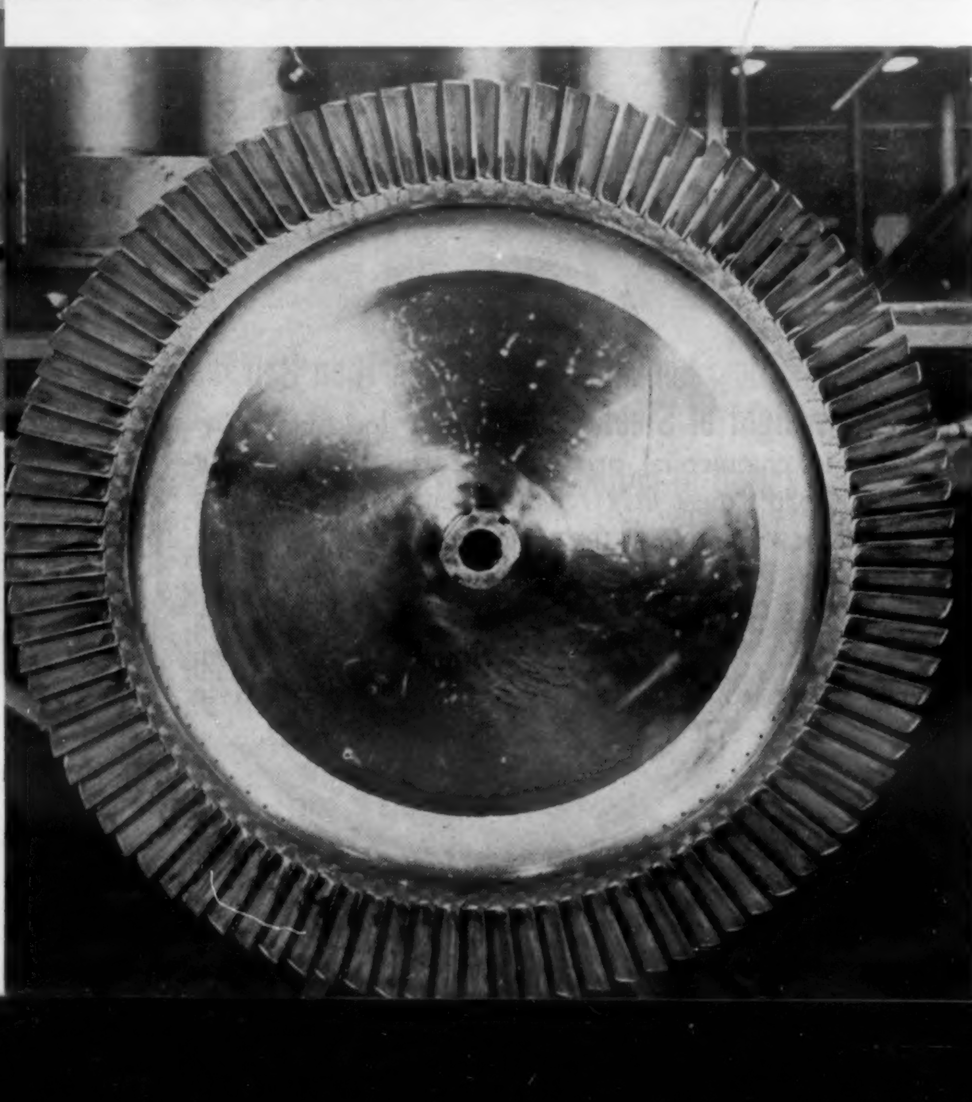


Silicone Rubber Joined to Aluminum in Diaphragm

Silicone rubber membranes as thin as 0.005 in. are joined to aluminum disks by Westinghouse Electric Corp. to provide a diaphragm sensitive to minute changes in air pressure and possessing a high operating efficiency under extreme conditions.

The diaphragm must be air tight, must not absorb moisture, be able to withstand the vibration and shock common to airborne apparatus, and the flexing of only a few thousandths of an inch must be essentially the same at −20 and 230 F as at room temperature. The bonding process developed is one requiring accurate control of process temperatures and times, curing cycle rates, and a high order of cleanliness.

The diaphragms are used in airborne equipment and power switchover gear.

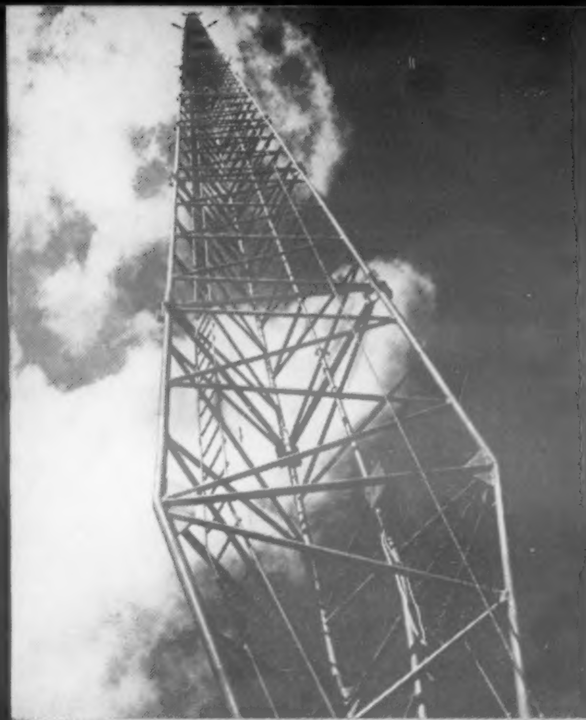


Combining Alloys in Turbine Wheel Conserves Critical Materials

Originally the turbine wheels of the G-E J-47 turbojet engine were made entirely of the Timken alloy, 16 chromium, 25 nickel, 6% molybdenum. In order to conserve critical alloying elements, the wheel was redesigned so as to use this high alloy only in that section of the wheel where its strength at high temperatures was actually required.

A rim of the Timken alloy is now welded to a flanged shaft made of low alloy steel of the 4340 type (1.75 nickel, 0.75 chromium, 0.25% molybdenum) which is heat treated to gain the high strength and toughness necessary in the shaft portion, but does not require resistance to heat or corrosion.

Stainless steel filler rods, lime coated, are used to weld the inner diameter of the high alloy rim to the outer diameter of the low alloy disk or flange. The former is preheated to 1100 F, the latter to 600 F, these temperatures being maintained throughout the welding operation. The welds are finally x-rayed for soundness.



High-Strength Low-Alloy Steels

by THE EDITORS, Materials & Methods

The steels known as high-strength, low-alloy steels are finding wide application in those fields where a reduction in weight or increased corrosion resistance means a considerable saving both in original and in operating costs.

To acquaint you with these steels, this manual covers:

- ***General Characteristics***
- ***Corrosion Resistance***
- ***Special Service Properties***
- ***Joining and Working Characteristics***
- ***Design Considerations***
- ***Applications and Economics of Use***

MATERIALS & METHODS Manual No. 102

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

FEBRUARY 1954

High-Strength Low-Alloy Steels—What They Are

The high-strength low-alloy steels are tonnage grades of steel given superior properties by the addition of a small amount of various alloys. The strength of these steels as measured by the yield point is about 50% higher than that of structural carbon steel. The resistance to atmosphere corrosion of some of these steels is 4 to 6 times that of carbon steel or 2 to 3 times that of copper steel.

Because of their superior properties, these steels can be used advantageously for construction of many products in any of three ways:

1. In equal sections to reduce maintenance costs and lengthen the life of the product, with no reduction of weight.
2. In reduced sections to decrease weight and increase capacity but with the same strength of life as existing equipment.
3. A compromise between (1) and (2) giving both a substantial increase in service life and a substantial decrease in weight.

The final design will depend in each case on the relative importance which the designer assigns to increased weight and longer life on one hand and to lighter weight and increased capacity on the other.

High-strength steels have been intimately associated with the lightweight development and have been used so extensively as a means of reducing weight that they are sometimes referred to as light steels, although they weigh the same per cubic inch as any other steels.

In the development and use of these steels considerable misunderstanding has been caused by the use of terminology such as high tensile steel, low alloy steel, mild alloy steel, and light weight steel. Some of these designations are inaccurate and misleading. At present the group of compositions is nameless, insofar as official classifications is concerned, but the term high-strength low-alloy steel has gained general favor and is now used by most producers. Moreover, there is no official definition of the properties and characteristics of steels qualifying in this group. One which has been adopted by the American Iron & Steel Institute follows:

"High-Strength Low-Alloy Steel comprises a specific group of steels with chemical compositions specially developed to impart improved mechanical properties and greater resistance to atmospheric corrosion than are obtainable from conventional carbon structural steels containing copper. High-Strength Low-Alloy Steel is generally produced to mechanical property requirements rather than to chemical composition limits."

"High-Strength Low-Alloy steel is generally intended for applications where savings in weights can be effected by reason of its greater strength and atmospheric corrosion resistance and where better durability is obtained because of these and other desirable characteristics."

These steels are normally furnished as-rolled, as-annealed, as-normalized, or as-stress relieved and are intended for use without further heat treatment except for preheating, postheating or stress relieving operations which are sometimes used in conjunction with metal-arc welding. They are generally available in the forms commonly supplied in carbon steel.

Throughout this manual high-strength low-alloy steel will be referred to as *high-strength steel*; plain carbon steel containing 0.20% copper will be referred to as *copper steel*; and plain carbon structural steel will be referred to as *carbon steel*.

General Characteristics

The high-strength steels, as has been indicated, were developed primarily to provide structural steels that would permit substantial weight saving in various types of construction. This could not be accomplished, however, without assurance that there would be no impairment of service life or safety and, consequently, provision against premature failure due to corrosion was of prime importance. Fortunately, some of the elements which impart strength to steel are also those employed to obtain good corrosion resistance. Conspicuous among these elements are copper, phosphorus, silicon, chromium, nickel, and molybdenum. Two or more of these elements in small percentages, combined with low carbon and varying degrees of manganese, constitute the chemical compositions of the principal steels now included in this group.

A minimum degree of several important properties must be possessed by a composition suited to the purposes for which this group of steels was designed. Otherwise, the steel would not adequately fulfill requirements in some one or more respects and would, therefore, be disqualified. Good resistance to atmospheric corrosion is needed in most cases; however, the degree necessary is obviously determined by the nature of the structure to be built and the environment in which it is intended to function. Thus, in railway freight car equipment and in mine cars, corrosion resistance is most important, but it may not be in certain parts of motor trucks and passenger motor vehicles, machine tools, and some structures employing heavy sections. This manual indicates how a determination can be made of the degree of corrosion resistance ordinarily needed to offset the reduction in thickness of high-strength steel members displacing heavier construction of carbon steel.

Service experience and exhaustive

testing of samples in various atmospheres have demonstrated clearly that the superior atmospheric corrosion resistance of certain high-strength steels is due to the more dense, tightly adherent, and highly protective rust coat, or oxide film, which forms on their surfaces. One particularly important characteristic of this rust coat is its uniformity. It is practically free from spalling and the formation of tubercules which aggravate pitting and cause corrosion to progress steadily. Paint and other protective coatings, such as zinc and certain enamels, adhere better to high-strength steels which possess good atmospheric corrosion resistance than to ordinary steel.

It is also reported that in certain special applications the use of these steels simplifies preparation of parts to be polished, painted, or plated.

Other characteristics of the high-strength steels including their workability are described in appropriate sections of this manual.

In barge service where corrosion and erosion are severe, some high-strength steels used in hull-plating will last twice as long as carbon steel.

Representative High Strength—Low Alloy Steels

Data given, except for noted exceptions, are for plate ½-in. thick in the hot-rolled condition

Brand Name	Composition, %											Yield Pt, Min, Psi	Ten Str, Min, Psi	Min Elong	Producer
	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Zr	Al				
Aldecor	0.12 max	0.15–0.40	0.08–0.15	0.05 max	0.35–0.75	0.35–0.60	—	—	0.16–0.28	—	—	50,000	70,000	[a]22%	Republic Steel Corp.
Cor-Ten	0.12 max	0.20–0.50	0.07–0.15	0.05 max	0.25–0.75	0.25 0.55	0.65 max	0.30–1.25	—	—	—	50,000	70,000	[a]22% [f]18%	U. S. Steel Corp. Republic Steel Corp. Sharon Steel Corp. Greer Steel Co. Algoma Steel Corp.
Republic Double Strength	0.12 max	0.50–1.00	0.04 max	0.05 max	—	0.50–1.00	0.50–1.10	—	0.10 min	—	—	50,000	70,000	[a]22%	Republic Steel Corp.
Dynalloy	0.15 max	0.60–1.00	0.050–0.100	0.050 max	0.30 max	0.30–0.60	0.40–0.70	—	0.05–0.15	—	—	50,000	70,000	[a]25%	Alan Wood Steel Co.
Hi-Steel	0.12 max	0.50–0.90	0.05–0.12	0.05 max	0.15 max	0.95–1.30	0.45–0.75	—	0.08–0.18	—	0.12–0.27	50,000	70,000	b–c	Inland Steel Co.
Mayari-R	0.12 max	0.50–1.00	0.06–0.12	0.05 max	0.10–0.50	0.30–0.70	0.25–0.75	0.40–1.00	—	—	—	50,000	70,000	[f]18%	Bethlehem Steel Co.
N-A-X High Tensile	0.08–0.15	0.50–0.75	0.04 max	0.05 max	0.60–0.90	Resid.	Resid.	0.50–0.65	—	0.05–0.15	—	50,000	70,000	c	Great Lakes Steel Corp. Republic Steel Corp.
Otiscoloy	0.15 max	0.90–1.40	0.08–0.13	0.04 max	0.10 max	0.30 min	Resid.	Resid.	—	—	—	50,000	70,000	[a–d]25	Jones & Laughlin Steel Corp.
Tri-Ten	0.25 max	1.30 max	0.045 max	0.05 max	0.10–0.30 max	0.30–0.60	0.50–1.00	—	—	—	—	50,000	70,000	[a]22% [f]18%	U. S. Steel Corp.
Tri-Ten "E"	0.25 max	1.30 max	0.045 max	0.05 max	0.10–0.30 max	0.20 min	0.50–1.00	—	V 0.02 min	—	—	50,000	70,000	[a]22% [f]18%	U. S. Steel Corp.
Yoloy	0.15 max	0.60 max	0.05–0.10	0.05 max	—	0.75–1.25	0.50–2.00	—	—	—	—	50,000	70,000	[a]22%	Youngstown Sheet and Tube Co.

NOTES:

All of these steels, in thicknesses up to and including ½ in., are capable of at least meeting ASTM Standard Specimen cold bend of 180 deg. over a diameter equal to the thickness of the material.

[a] *% elongation in 2 in., ASTM Standard Flat Specimen.*

[b] $\frac{1{,}500{,}000}{T.S.}$ *min. % elongation in 8 in., ASTM Standard Flat Specimen.*

[c] *For thicknesses under 5/16 in., 22% min. elongation in 2 in., ASTM Standard Sheet Specimen.*

[d] *For thicknesses under 5/16 in., 25% min. elongation in 2 in., ASTM Standard Sheet Specimen.*

[e] *Typical value for ½ in. plate, 27% in 8 in., ASTM Standard Flat Specimen.*

[f] *Percent elongation in 8 in., ASTM Standard Flat Specimen.*

How High-Strength Low-Alloy Steels Were Developed

Following a number of sporadic attempts, both in America and abroad, the weight saving era in world-wide construction, which was in part responsible for the development of the high-strength low-alloy steels, finally got well under way in the early 30's. Experimental applications of various metals had been made since the turn of the century to meet a growing consciousness that needless weight in structures was a costly drag on their useful functions and a serious drain on basic raw materials. Steels higher in strength than usual structural grades had been used over a period of years in the parts of some bridges, ships, and in subway cars for the City of New York.

Various objectives were sought in these early instances of weight reduction. Engineers in Great Britain had economy in ocean freights and handling charges in mind, principally, and made some progress toward these ends through weight reduction by the use of carbon steels containing generous additions of silicon and manganese or chromium and copper.

The European engineers made use of similar steels, and early in 1933 the Germans completed the construction of the "Flying Dutchman", the first light-weight "streamlined" train ever built using a high-strength steel. This composition contained additions of silicon, manganese, and copper and was known as St. 52.

In America, early in the century, some use had been made of a 3¼% nickel steel in certain parts of bridges, and somewhat later a steel containing about 1.6% manganese was employed as an alternate. The conservation of weight and space were early considerations in this country.

The high-strength construction steels, applied with some effect in the early years of the development, were those using carbon with nickel, manganese, or silicon as their principal strengthening elements.

But it was not until early 1933 that forerunners of the group of steels now known as high-strength low-alloy steels had been developed and introduced initially in the transportation field. It was then that a survey of the railroad industry disclosed a desire on the part of its leading engineers to eliminate the excess dead weight existing in rolling stock. These engineers were asked what was required in the way of improved properties in steel to provide lighter and more efficient structures, while at the same time sacrificing nothing in the service life or maintenance of the equipment.

Their wants were almost identical. They needed greater strength, at the yield point, to permit a substantial increase in unit stresses, and thereby make possible a proportionate decrease in section modulus. This meant the employment of lighter gages and, consequently, their next demand was for a greater degree of resistance to corrosion in order that the rate of attack would be retarded sufficiently to warrant the reductions made in the sections employed. Next they required a composition that could be formed easily, hot or cold; readily welded without heat treatment and generally without the need of subsequent annealing, or stress relieving.

It was requested also that these properties be provided in the as-rolled condition of the steel, because obviously large structures such as railroad freight and passenger cars could not be subjected to heat treatment after fabrication. Lastly, it was asked that all of these improved properties be integrated in a steel of relatively low cost. These specifications constituted quite a large order, but the important advantages so clearly indicated proved a sufficient spur to ingenuity, thus causing the metallurgists to bring to fruition developments which had been under way for years in efforts to develop steels of such a type.

Since the introduction of these steels in 1933, progress has been rapid and it is now evident that as the great economies to be realized are better known, more and more structures will be built of high-strength low-alloy steels.

Corrosion Resistance

In the manufacture of steel, one of the major operations involves the separation of the ore into its principal components, iron and oxygen. An article manufactured of steel always tends to revert to its original state, commonly known as iron oxide or rust. This change in form, or wasting away, is characteristic of all structural metals and is commonly referred to as rusting or corroding. Oxygen is the most important factor in this natural phenomenon particularly in the presence of water, either as vapor in the atmosphere or as a liquid.

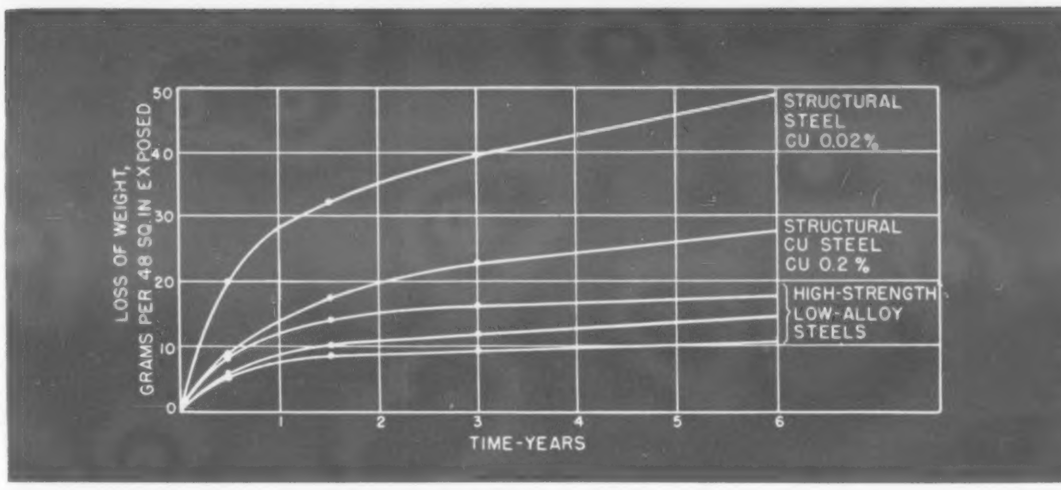
This tendency to corrode can be minimized only by interposing between the metal and the environment some barrier or defense against continued attack. Such a barrier may be a very thin invisible and continuous oxide film as is formed on stainless steel. On the high-strength steels it may be a visible somewhat thicker coating of rust which is much more adherent and impervious and, under most conditions, a more effective barrier than the rust which forms on carbon steel. An oxide will form on the high-strength steels which possess outstanding atmospheric corrosion resistance. A typical characteristic of the rust formed on carbon steel is that it is loose and porous and will, under some circumstances, accelerate attack or induce localized corrosion. Thus pits are developed which may ultimately perforate the metal. A barrier can also be provided by applying a layer of another metal, or a coating of paint, or some other

protective substance.

The rate at which the corrosion of steel proceeds depends upon at least two principal factors: 1) the environment to which the material is subjected, and 2) its chemical composition. For example, carbon steel corrodes at an extremely slow rate in dry inland atmospheres, while in a contaminated industrial atmosphere its tendency to corrode is greatly increased. On the other hand, the highly alloyed stainless steels suffer no measurable corrosion loss in most media, although in some acid bearing water there may be a perceptible loss. Tests by the U.S. Bureau of Mines, Investigations 4996, show high-strength, low-alloy steel superior to stainless steel for regenerative air preheaters. The high-strength steels occupy an intermediate position, losing much less weight in most environments than carbon steel and, of course, considerably more than stainless. The most striking difference in the corrosion rates of ordinary steel and of high-strength steel is found when they are exposed to several contaminated industrial atmospheres. Since all carbon steels are subject to loss of weight (i.e., thinning) by corrosion, preventive measures must be taken, otherwise, their safe and economic use is limited.

Commonly effective measures for minimizing corrosion will not suffice unless care has been exercised to keep the surface conditions of the metal free from entrapped dirt and moisture in laps and on ledges, because such conditions cause greatly accelerated attack at those locations. A more detailed consideration of this matter is given elsewhere in this manual. A considerable amount of data have been published from time to time covering the corrosion testing of steels. (See bibliography.)

It is believed that only a brief summary need be given here regarding some of the general trends disclosed.

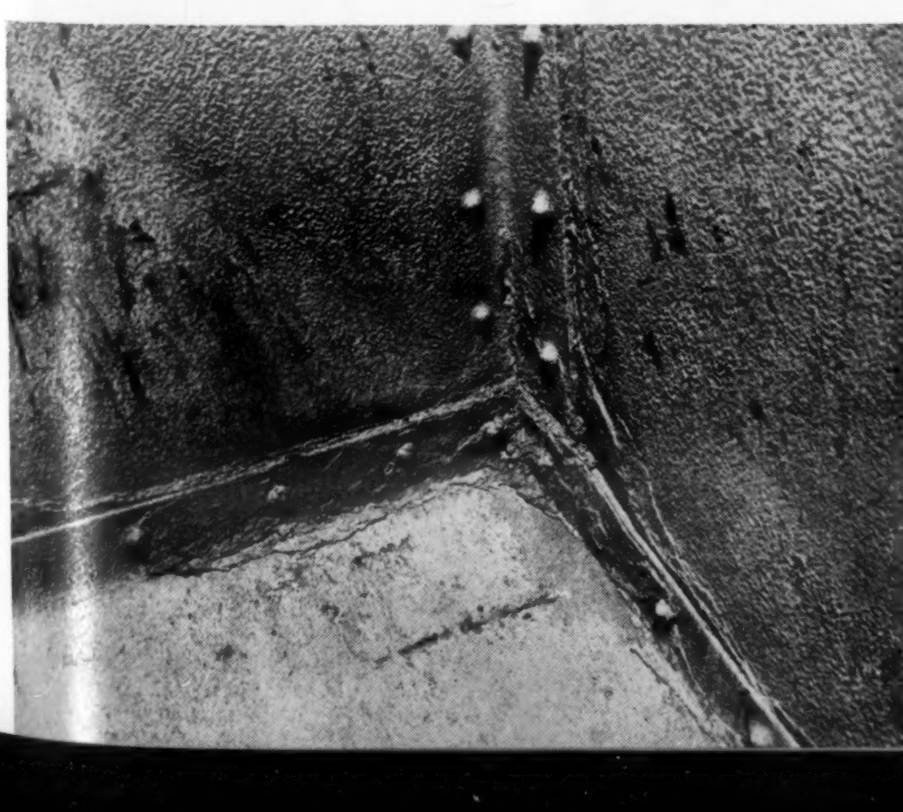


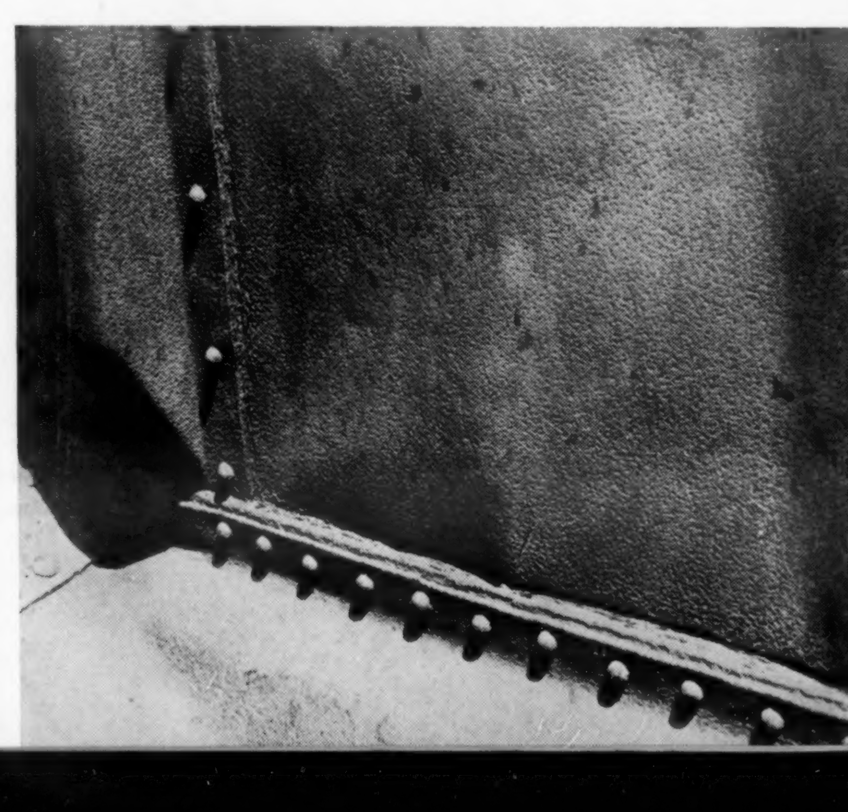
Time-corrosion curves for steels typical of their classes after exposure to industrial atmosphere.

Atmospheric Corrosion

The copper content of a carbon steel determines its degree of resistance to atmospheric corrosion, and as the amount of this element increases to about 0.25%, a progressive improvement is shown. Carbon steels now contain small and varying quantities of residual copper, and it is expected that the residual copper content in steel will continue to increase in the future. As a consequence large differences are expected in the resistance of this steel to atmospheric corrosion. Thus, no single index of performance for carbon steels is possible. On the other hand, the copper steels commonly containing 0.20% minimum copper, give consistent and reproducible results when exposed to the atmosphere, and, consequently, can be used as an index. The atmospheric corrosion resistance of high-strength steel varies with the combination and content of those alloying elements most effective in building up this resistance. Several steels of this type possess two to three times the atmospheric corrosion resistance of copper steels, as has been demonstrated over a period of some years. Using the known criterion that copper steels (0.20% copper minimum) have approximately double the resistance to corrosion in the atmosphere of a carbon steel containing 0.02% copper, the more resistant high-strength steels offered to the trade possess in the main, four to six times the corrosion resistance of ordinary steel. Typical time corrosion loss curves for representative steels of the above mentioned classification, after exposure in an industrial atmosphere, are shown in accompanying drawing.

An outstanding characteristic of all high-strength, low-alloy steels is excellent resistance to atmospheric corrosion. In the illustration at left, a plain carbon steel hopper car shows the formation of rust and spalling which occurs. At the right is a hopper car made of high-strength, low-alloy steel showing how a dense, adherent and relatively impervious rust forms to protect the metal underneath.





This fishing vessel is constructed almost entirely of high-strength, low-alloy steel. Only the mast funnel and some minor parts are made of carbon steel.

Sea Water Corrosion

The average penetration of ordinary steel, copper steel, wrought iron and representative high-strength steels is about 0.004 in. per year for each surface exposed. However, in general pitting on high-strength steels is only about one-half the depth of that on carbon steel.

Corrosion in Inland Waters

Tests in uncontaminated running brook water having high oxygen content indicate similar corrosion resistance for carbon steel, copper steel, and various high-strength steels.

Tests in various river waters show greater corrosion with increasing contamination for all steels. Although there is little difference between the performance of carbon steel and the high-strength steels in river waters having little contamination, the comparative resistance to corrosion of some high-strength steels improves as the contamination increases.

Corrosion in Soil

Tests by the National Bureau of Standards in many soils show that the corrosion resistance of representative high-strength steels is not sufficiently better than that of carbon steel to warrant claims of superiority in most instances. This type of corrosion is characterized by a great tendency toward localized pitting which results in large variations in loss of weight between individual samples of the same steel.

Corrosion in Service Applications

As has been previously mentioned, the corrosion resistance of a material cannot be expressed quantitatively (as yield point is described, for instance) because it is only a relative term. Furthermore, no material is resistant to all corrosive conditions to which it might conceivably be exposed. Its performance can only be compared with that of other materials under similar conditions.

This contention is in accord with the point of view that atmospheric rack tests do give strictly comparative results under a specific environment. Such tests differentiate between the performance of various steels and permit a close evaluation of the trends in weight loss due to corrosion.

The superior atmospheric corrosion resistance which most of the high-strength steels have shown in rack tests has been confirmed by their performance in many different kinds of service. This superiority is particularly evident in all applications in which the materials are subjected principally to atmospheric corrision. As an illustration, after about 10 years' service, there was practically no loss in thickness in the uppermost area of open top railroad car side sheets made of high-strength steel having good atmospheric corrosion resistance. Copper steel in a similar location and service lost approximately 0.01 in., and carbon steel three times this amount. In another instance where both compositions were exposed for 11 years in a highly contaminated industrial atmosphere, carbon steel lost ten times the weight lost by one of the high-strength steels having good atmospheric corrosion resistance.

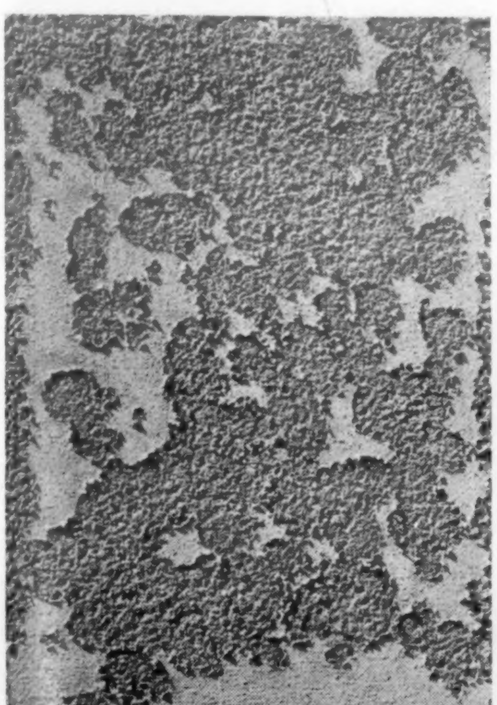
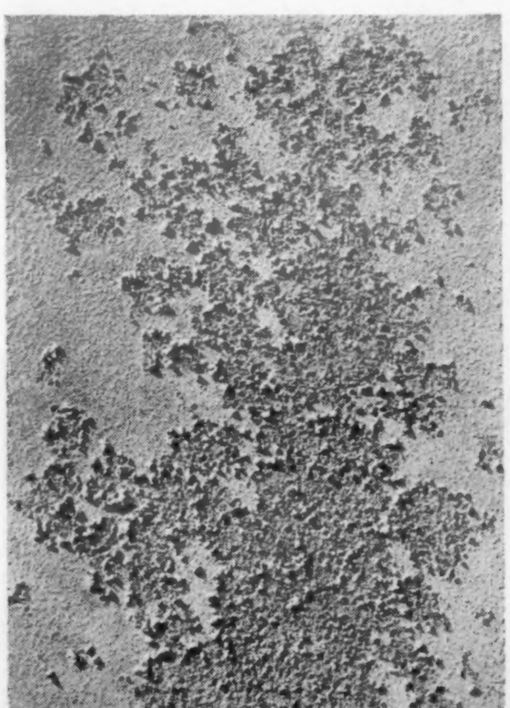
In those applications in which the materials are subjected to atmospheric corrosion, but also to abrasion and attack from leachings, the superiority of high-strength steel over carbon and copper steels remains substantial. For instance, after about 13 years' service, the loss in thickness at the lower edge of the side sheets of open top railroad coal cars constructed of high-strength steel was approximately 0.02 in., while copper steels in a similar location and service lost two and one-half times this amount. Even where abrasion and attack from leachings are most severe in such service, the superiority of some high-strength steels over carbon and copper steels is still marked. This is shown by losses in thickness of approximately 0.07 in. for a high strength steel of good atmospheric corrosion resistance, approximately 0.10 in. for copper steel, and about 0.16 in. for carbon steel in the lower portions of the floors and in the hopper chutes. This superiority in performance has also been verified by the improved service life of mine cars constructed of high-strength steels.

In a ten year service test on a steamer which operated in a highly contaminated river, a high-strength steel lost approximately 0.02 in., copper steel approximately 0.03 in., and carbon steel 0.04 in. in thickness slightly above the water line. At a location somewhat below the water line, the high-strength steel lost approximately 0.04 in. only; the copper steel approximately 0.09 in carbon steel lost its full original thickness of 0.11 in.

Protection by Coatings

In many applications, coatings of paint are applied to provide protection against corrosion. The most important item in obtaining good paint protection for a metal is the proper preparation of the surface before the paint is applied. The protective value of properly applied paint, due to better adherence to high-strength steels, endures longest on these steels, not so long on copper steels, and for a much shorter time on carbon steels of low copper content. This better adherence of paint to the surfaces of high-strength steel is attributed to the less voluminous rust formed on the steel where moisture penetrates through the paint. The lighter, more adherent rust which forms on high-strength steel has less tendency to lift the paint. The tendency for the rust on these steels to spread laterally is also much less marked.

Galvanized high-strength steels are sometimes required in special applications where corrosion is severe, for instance where chlorides are present. It has been found that these steels, when galvanized, are much more resistant to salt conditions than galvanized copper steel, which in turn, is superior to galvanized carbon steel.


Recent studies have shown that the characteristics of steels being covered have considerable effect upon the life of coating systems. These specimens illustrate that fact. Specimens of painted structural carbon steel (left), structural copper steel (center), and a high-strength, low-alloy steel (right) are shown after 5½-year exposure in an industrial atmosphere at Kearny, N. J. The specimens were prepared by exposing hot rolled samples in the atmosphere for one month, wire brushing and then painting with a 1-mil coat of red lead paint and a 1-mil coat of iron oxide paint.

High-strength steels are available in both sheet and strip forms for such applications. The adherence of zinc coating to these steels in all usual fabricating operations is comparable with that on carbon and copper steels. Where hot-dip galvanizing is necessary, special practices, particularly in pickling, are required because the most important feature in obtaining good adherence is primarily the development of a thoroughly clean surface on the base metal.

High-strength, low-alloy steel was used to make 7000 seat brackets in the addition to the stadium of the University of Washington in Seattle.

Special Service Properties

The use of high-strength steel in gas cylinders has made possible fast, easy fabrication and has achieved a 23% reduction from weight of carbon steel, without loss of strength or resistance to impact.

Notch Toughness

Toughness, as measured in a notched bar test, is of interest because it reflects the behavior at notches in actual structures. Such notches might result from improper design or fabrication, or may be present unavoidably. It must not be concluded that the notched bar values will be reflected primarily in the behavior of large structures, but the trends will be recognized unmistakably. For example, one of the criteria of notched bar toughness employed today is the refrigerated temperatures at which the notched bars are brittle. An actual structure may not exhibit brittleness at precisely the same temperature, even in the presence of a notch, but the steel which preserves its toughness to a lower temperature in a notch bar test will likewise preserve its toughness to some lower temperature in an actual structure.

High-strength steels are better than carbon steels in notch toughness, whether the notch toughness be considered in terms of the number of foot-pounds at room temperature or in terms of the degrees Fahrenheit refrigerated temperature down to which they preserve their toughness.

These advantages in notch toughness are reflected in a superior performance of actual structures. A structure built of high-strength steel, as compared with a similar and correspondingly heavier structure of structural carbon steel, will exhibit superior resistance to fracture under overload at notches, re-entrant angles, or under other conditions of restraint.

In commenting on notch toughness and/or sensitivity producers had this to say:

Question: Some authorities claim that welded structures of a monolithic character, such as certain types of bridges and ships, require steels having a substantially less notch sensitivity than exhibited by ordinary structural grades. Do you recommend any of your high-strength steels for such applications?

Answer: 1. "The . . . high-strength steels are much more notch resistant than ordinary structural steel. The use of such high-strength steels will therefore be advantageous in structures where a higher degree of notch resistance is desired."

2. "Our high-strength steels may be reported as demonstrating, by lab test and service, a uniformly higher toughness over ordinary structural steel. However, intelligent design that is wary of and seeks to eliminate re-entrant angles, etc., a know-how of welding construction, are all more important than lab tests of polished specimens. No good quality in a steel can be sufficient to overcome, in the long run, a bad design. Variations in notch sensitivity in the as-rolled condition from heat to heat and gage to gage will be about the same as in structural grades, although the high-strength steels will average higher values than structural grades at low temperature."

3. "Notch sensitivity is not a requirement of specifications covering materials for welded bridges and ships and we would, therefore, not hesitate to furnish either carbon steel or our high-strength steels for those purposes as long as they meet the specification requirements in other respects."

Fatigue Resistance

The endurace limit of a material, as determined by testing polished specimens, is considered to have little bearing on the fatigue resistance of full-size structures. Design and fabricating practices are far more important in this respect, since failures of structural members, subject to alternating or pulsating stresses, generally originate at some surface notch or discontinuity.

Laboratory tests of polished fatigue specimens indicate a trend in superiority of high-strength steels over structural carbon steels as evidenced by higher endurance limits for the former. The ratios of endurance limit to tensile strength are 0.6 to 0.7 for high-strength steels, whereas with carbon steel they are usually about 0.5.

Producers of high-strength steels, likewise, were asked to comment specifically on fatigue resistance and replied as follows:

Question: Endurance limit, as determined on polished laboratory specimens, has what bearing on structural designs involving fatigue?

Answer: 1. "Regarding fatigue, such evidence as we have denies any correlation between the endurance limit as determined from polished specimens, and the fatigue strength of riveted or welded joints. . . . Further research is proposed; but the evidence indicates that the stress raising characteristics of joint geometry will completely overshadow differences in composition of steel."

2. "Absolutely none except a very rough empirical relation. We do not make or believe in endurance limit tests. Design and construction are far more important."

3. "In testing steels to be used in structural designs involving fatigue or corrosion fatigue conditions, several specimens of various analysis . . . should be prepared and tested in the corrosive media or atmosphere expected to be encountered in actual service. In general, the steels that would stand up better than other steels in these types of laboratory tests, will show better results in actual service. However, the best test is one of service itself."

4. "Probably none as applied to design. Laboratory fatigue tests are fatigue tests of the metal, per se, and not generally of design."

5. "We believe that the test results of polished laboratory test specimens have very little bearing on structural designs involving fatigue life of a structure. Polished specimens may, however, serve for comparative purposes of various structural materials and do indicate trends toward superiority of one material over another, all other factors being equal."

Abrasion Resistance

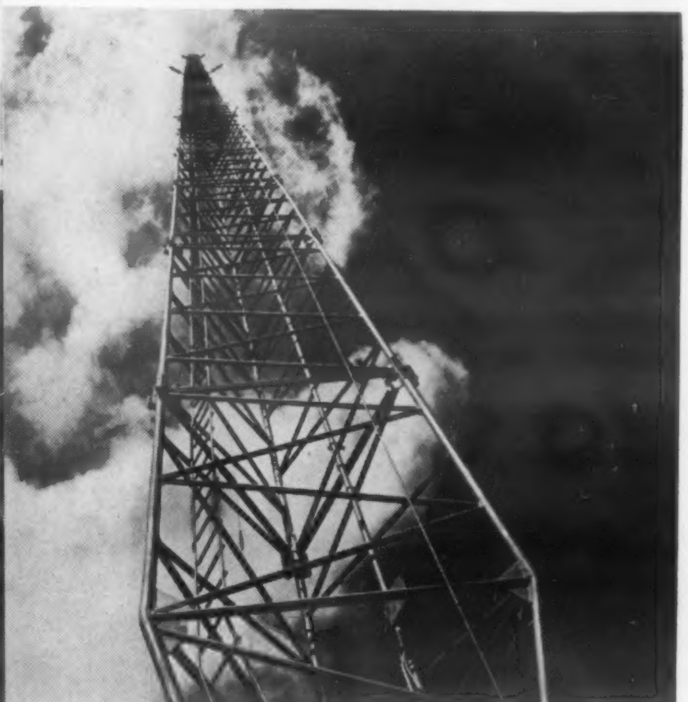
It is difficult to make a general statement with respect to the resistance to abrasion of any material, for the reason that there are many kinds of abrasion associated with different abrasive substances, and because abrasion is frequently combined in service with corrosion. There is general agreement, however, that the resistance of various steels to abrasive action increases with strength and, to some extent, with carbon content. Service tests have demonstrated that the abrasion resistance of the high-strength steels, with their inherently higher strength, is considerably greater than that of structural carbon. This superiority is especially pronounced where abrasive action is encountered along with corrosion, as in most mobile structures which are used for the transportation of bulk ladings, such as open-top railroad freight cars, barges, mine cars, dump-truck bodies, and similar applications.

Joining and Working Characteristics

The high-strength steels considered in this manual are as readily weldable as structural carbon steels: indeed, welding characteristics have been a foremost consideration in their development. In heavier structures, designed for light weight construction, overall welding costs for these compositions will be somewhat less than for carbon steel due to the smaller volume of welding material required in joining the reduced sections.

However, the maximum benefits to be derived from the use of high-strength steels will be obtained only in properly designed welded construction. The cost of welded structures should be less than that of riveted structures; fewer operations are required, and the volume of material used is reduced by the simplified welded construction. These lower costs will be most fully real-

By changing from carbon steel construction to high-strength steel, power shovel manufacturers have increased dipper capacity as high as 67%. This 45-cu yd shovel is an example of what can be done with high-strength steel.



Corner verticals in this 750-ft high radio broadcasting tower were made of high-strength steel bars ranging in diameter from 2-¼ to 2-⅞ in.

ized when engineering, management, and production personnel understand welding and base their designs, production planning, and shop operation upon it. In addition to the importance of designing expressly for welding, accurate layout, good fitting, preassembly, positioning, and in general, the use of welding jigs and fixtures are essential to economic welded construction.

High-strength steels, because they are low in carbon content, do not require special handling in most welding processes. They can be readily welded to each other and to carbon steel. Preheating is not required to any greater extent when welding high-strength steels than with carbon steel. Whenever stress relief annealing is necessary, substantially the same practice is used as with carbon steel.

Metal Arc Welding

Arc welding encompasses both shielded metallic arc and submerged arc welding, either of which may include manual or automatic machine welding. In welding high-strength steels the same techniques and same type of electrodes are used as for welding mild carbon steel. Special alloyed electrodes are not essential because of the corrosion resistance provided by the enrichment of the weld deposit due to the intermingling of the alloying elements from the base metal. The cast character of the weld deposit also contributes to corrosion resistance. Service experience and extensive tests have demonstrated that the corrosion resistance of weld deposits is equal to that of the base metal.

The use of ordinary unalloyed electrodes with the high-strength steels also provides welds of adequate strength together with maximum ductility and freedom from cracking. Covered electrodes of the E-60 group or equivalent are recommended for metal arc welding and have been employed generally.

Submerged Arc Welding

The same adequate properties as those described above result when the submerged arc process is employed. The welding wire normally used for carbon steel is also recommended for submerged arc welding of high-strength steels. High welding speeds obtainable by this process on sheets and light plates, result in substantial economies. This process is an excellent method of joining high-strength steels in a wide variety of structures. Moreover, since laps can be eliminated almost entirely and welds are continuous, the structure can be sealed against moisture and corrosion thereby minimized.

Spot Welding

High-strength steels in thicknesses of about ⅛ in. and less are spot welded with about the same welding conditions of time, pressure, and current as are used in the spot welding of carbon steel. Surface conditions are important and the material to be welded should be thoroughly cleaned either by pickling or sandblasting. Uniformly good results cannot be obtained with grease, paint, or rust on the surfaces of the material, but a light film of oil following pickling is not considered detrimental.

Spot welds in the high-strength steels have adequate ductility and their shear strength is proportionately greater than that of spot welds in ordinary steel. These steels are readily spot welded to each other and to carbon steel provided such steels are sufficiently spot weldable in themselves. They are also readily spot welded to the austenitic stainless steels. The spot welding of high-strength steels to nonferrous metals should not be undertaken without careful preliminary investigation.

Under special conditions other welding processes can be employed, but they are not commonly used.

Savings Through Welding

It is pointed out elsewhere in this manual that the substitution of high-strength steels for structural carbon steel may achieve weight reduction averaging about 25% in most structures. Where welding is used rather than riveting, a still further weight saving is effected and, in some instances, the combined savings are most substantial, even approximating a total of 40 to 50% in certain components of some structures.

Riveted construction involves many corrosion traps such as laps and seams, the most harmful of which are horizontal ledges formed by lapped joints. At these locations moisture is trapped between the faying surfaces, and dirt and coal fines, which frequently contain sulfur and other corrosive compounds, accumulate upon the ledges. Such conditions result in localized corrosion which may cause premature failure. Due to these conditions, high-strength steels having good atmospheric corrosion resistance have sometimes failed locally, while the adjacent metal was virtually unaffected. Continuous welds which seal laps and seams and thus prevent the forced penetration by moisture contribute substantially to the durability of the structures. Such continuous welds in properly designed construction, by whatever process made, form an important and effective safeguard against premature deterioration and add to the service life of the structures, thus avoiding costly maintenance and rebuilding operations. Too much emphasis cannot be placed

upon the importance of self-clearing and self-draining structures. This can best be accomplished in properly designed welded construction.

Riveting

When fabricating high-strength steels by riveting, mild steel rivets, appropriately spaced, have frequently been used. However, the use of high-strength steel rivets is desirable especially where shearing stresses are high or where corrosive or abrasive action is severe.

Rivets made of high-strength steels can be cold driven if their diameters do not exceed 3/8 in.; hot driving is recommended for larger sizes. These rivets should be heated to 2000 to 2150 F for driving with an air hammer, and to 1700 to 1900 F for machine driving.

Cold Forming

High-strength steels, despite their high yield points, can be satisfactorily worked in press brakes, drawbenches, presses, and other equipment used for cold forming, even when these forming operations are quite severe.

The principal differences in the cold forming characteristics of high-strength steels and carbon steel can be seen in the accompanying diagram. High-strength steel, because of its greater strength, generally requires more force to produce a given amount of permament set in sections of equal thickness. This difference is proportional to the heights of the two "flow curves" shown. However, because high-strength steel can usually be employed in thinner sections, the force required in most instances is little greater than for ordinary steel.

The height of the flow curves at a given strain also represents the strength of the formed part. A comparison of the two flow curves in the diagram shows that, for the same part formed from the two steels, the strength of the high-strength steel part is substantially greater than that of the part formed from carbon steel. When working with high-strength steel, somewhat greater allowance for spring-back must be provided in the forming dies. The amount of spring-back is proportional to the height of the flow curve and the relative amounts for high-strength and carbon steel, for a strain of 0.2 are shown in the diagram.

The changes in practice necessary for cold forming high-strength steel consist chiefly in making provision for more liberal radius of bends, slightly increasing die clearances, and allowing for more spring-back. These changes cause no serious difficulties after the shop personnel becomes familiar with the characteristics of these steels.

It is recommended that, for cold forming, the inside radius of the bend be at least equal to the thickness of the material up to 1/16 in. inclusive, at least twice the thickness of the material for thicknesses over 1/16 in. to 1/4 in. inclusive, and three times the thickness of materiai for thicknesses over 1/4 in. to 1/2 in. inclusive. High-strength steels of drawing quality can be worked with somewhat smaller radii than those recommended above.

The usual precautions and practices common to the successful forming of carbon steel are equally important in forming the high-strength steels. Greater deformation can be accomplished if the bending or drawing operations are performed at moderate speeds. It is preferable to avoid these operations in temperatures below 60 F.

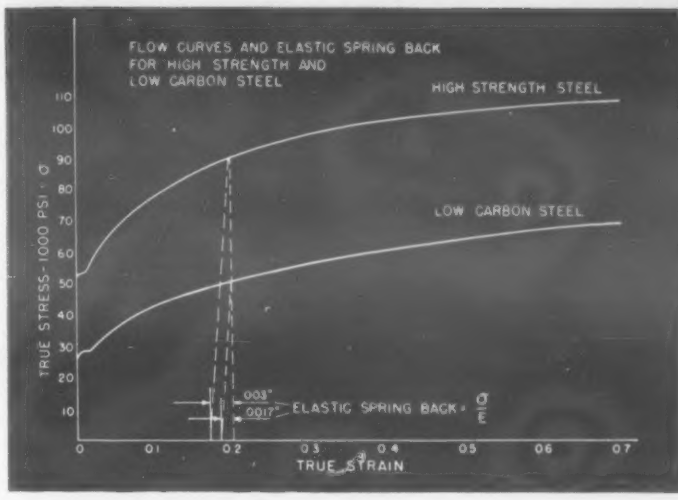
It is not possible in some instances to obtain hot rolled high-strength steel shapes in sections as light as desired. In such cases a much closer approach to the maximum possible weight saving can be accomplished by cold forming a corresponding shape from flat rolled steel. A fairly complete range of light, cold formed sections, such as angles, Z-bars, and channels is now available. Recent improvements in forming equipment, such as in stretch bending or tangent bending machines, makes the bending of these sections, as well as of eccentric sections possible.

Gas Cutting and Coping

The high-strength steels can be gas cut economically. Cuts are smooth and approximately the same speeds and torch adjustments are used as for cutting carbon steel. Gas cutting produces no harmful hardening in the heat affected zone.

Fabricating experience has indicated that certain precautions should be taken in coping steel. The following suggestions are considered good shop practice for both high-strength and carbon steels:

When coping these steels, the tools should have a rounded corner since sharp cornered tools tend to form notches which cause cracks. Burrs and fins should be removed if coped edges are to be bent cold.



Slightly more force per unit of thickness is required to attain permanent set in high-strength steel than is needed for low carbon steel.

Hot Forming

High-strength steels are readily hot formed, and this practice is universally recommended for all thicknesses in excess of 1/2 in. Temperatures of 1450 to 1600 F at the dies usually give most satisfactory results. Due to their low alloy content, these steels do not harden appreciably upon cooling from hot forming temperatures, either in air or by the quenching action of the cold die surfaces. The mechanical properties of these steels are only slightly affected by hot forming; hence, no subsequent heat treatment is necessary to restore their original properties. It is recommended that the producers of the grades employed be consulted as to the proper temperatures to be used in operations involving forging, normalizing or annealing and stress relieving.

Miscellaneous Operations

Shearing, punching, reaming, sawing, milling, and drilling operations can be performed on high-strength steel with little or no deviation from the practices employed with carbon steels. The reduction in thickness which usually accompanies the substitution of high-strength steel should compensate for the slight increase in force required to perform most of these operations. In shearing and punching, tighter and more secure clamping should be used because the high-strength steels tend to pull more than carbon steel. It has also been found that slight reductions in cutting speeds result in increased tool life.

Design Considerations

Design Specifications for High-Strength Steels

½ In. and Under in Thickness

ALLOWABLE UNIT STRESSES, PSI	
Axial tension, net section	27,000
Tension in extreme fibers of sections subject to bending	27,000
Axial compression, gross section	27,000
Average unit stress in concentrically loaded columns	
Riveted ends (L/r less than 125)	$22{,}000-0.56\ (L/r)^2$
Pin ends (L/r less than 110)	$22{,}000-0.72\ (L/r)^2$
L = length of member, in inches	
r = least radius of gyration of member, in inches	
Compression in extreme fibers of members subject to bending	
Rolled shapes, plate girders and built-up I-shaped sections	
For $\frac{Ld}{bt}$ less than 375	27,000
For $\frac{Ld}{bt}$ greater than 375	$\dfrac{10{,}300{,}000}{\frac{Ld}{bt}}$
Formed I-shaped sections	
For $\frac{L}{r_y}$ less than 95	27,000
For $\frac{L}{r_y}$ greater than 95	$\dfrac{244{,}000{,}000}{\left(\frac{L}{r_y}\right)^2}$
L = unsupported length, in inches	
d = depth of member, in inches	
b = width of flange, in inches	
t = thickness of flange, in inches	
r_y = radius of gyration about centroidal axis parallel to plane of bending, in inches	
Shear in beam and girder webs, gross section	16,000
Diagonal tension in webs of girders and beams, at sections where maximum shear and bending occur simultaneously	27,000
Shear in power-driven rivets (ASTM A 195-52-T)	20,000
Bearing on power-driven rivets (ASTM A 195-52-T), milled stiffeners and other parts in contact	40,000

Minimum Thickness of Material

Projecting elements of members, such as legs of angles or plates of girders, columns or other members, subjected to axial compression or compression due to bending, shall have ratios of width to thickness not greater than 11.

In compression members, the unsupported width of web or cover plates shall not exceed 34 times the thickness.

In either of the above cases, when a segment of a member exceeds the above limits, there are two alternatives.

(1) The maximum allowable compressive stress in the element shall not exceed that given by the formula:

(a) For projecting elements supported on only one edge,
$s = 49{,}000 - 1960\ (b/t)$

(b) For plate elements supported along both edges,
$s = 49{,}000 - 640\ (b/t)$

where

s = allowable compressive stress, in pounds per square inch
b = width of plate element, in inches
t = thickness of plate element, in inches

(2) The member shall be considered acceptable when that portion of the plate width no greater than the limiting width satisfies the stress requirements.

Webs of girders and beams should have a thickness of not less than 1/135 of the distance between flanges or side plates.

Stiffeners

Bearing stiffeners shall be placed in pairs on the webs at framed ends and at points of concentrated loads.

Stiffeners shall also be required at all points where the greatest shearing stress in the panel exceeds $29{,}000 - 250\ (h/t)$, in which

h = clear depth of web, in inches
t = thickness of web, in inches

Intermediate stiffeners may be omitted if the clear depth of the web is less than 52 times the thickness.

The clear distance between intermediate stiffeners, where stiffeners are required, shall not exceed the clear depth of web or that given by the formula:

$$d = \frac{116t}{\sqrt{\frac{v}{5700} - \left(\frac{100}{h/t}\right)^2}}, \text{ where}$$

d = clear distance between stiffeners, in inches
v = greatest shearing stress in the panel, in pounds per square inch

The principles of engineering mechanics used in the design of all engineering structures are the same, regardless of the material used in their construction. Once a knowledge of the unique characteristics of each material of construction has been acquired, problems of design take on the familiar pattern of analysis and of endeavor to utilize the material effectively and economically. High-strength steels are no exception. Their proper utilization is largely an extension of the vast experience accumulated over many years in using structural carbon steel. This long and well established record of structural carbon steel is an invaluable foundation upon which to base the use of the relatively new high-strength steels.

Structural members are generally proportioned on the basis of allowable or working unit stresses which are determined by dividing a strength property of the steel for the particular member by a suitable factor of safety. The strength property upon which most designs are based is the yield point, since it is the stress at which permanent set begins. Here lies one of the intrinsic values of high-strength steel in that they have a minimum yield point of 50,000 psi, approximately 50% higher than the 33,000 psi yield point for structural carbon steel. Thus, for members in axial tension and for short, compact compression members, for which the allowable stresses are usually directly proportional to the yield point of the steel, 50% higher working stresses may be used. In a given application, where the allowable tensile stress has been 18,000 psi for ordinary structural steel, the allowable tensile stress for high-strength steel would be 27,000 psi.

The strength of columns, laterally unsupported beams, and structural members composed of flat plate elements in compression is often governed by the resistance of such members to failure by buckling. In such cases, the comparable stresses for high-strength steel and structural carbon steel are not directly proportional to the yield points of the steels, although they are, in a sense, a function of the yield point. But even here, because of their higher yield point, high-strength steels generally permit the use of higher al-

lowable stresses without impairing the factor of safety against failure.

The outstanding advantage to be derived from the use of high-strength steels, as compared to structural carbon steel, is the weight saving without loss of useful life or safety of a structure, or the added life and ability of the structure to withstand increased service load without any increase in weight. Based upon the allowable tensile stresses for the two grades of steel, it is obvious that only two-thirds as much high-strength steel is required to provide the same strength as is in a member of ordinary structural steel. Similarly, a member of high-strength steel of the same section and weight as one of structural carbon steel would insure the member against 50% greater static loads. Experience has demonstrated that if a structure intended for carbon steel construction is redesigned for high-strength steel, the overall weight saving in the composite structure of various types of members is at least 25% and, in some instances, substantially higher.

The accompanying brief design specifications for a high-strength steel are based on a yield point of 50,000 psi and are comparable to specifications permitting an allowable tensile stress of 18,000 psi for structural carbon steel. Space limitations permit only this brief discussion of design. For a more elaborate treatment of the subject of design, the references listed in the bibliography should be consulted.

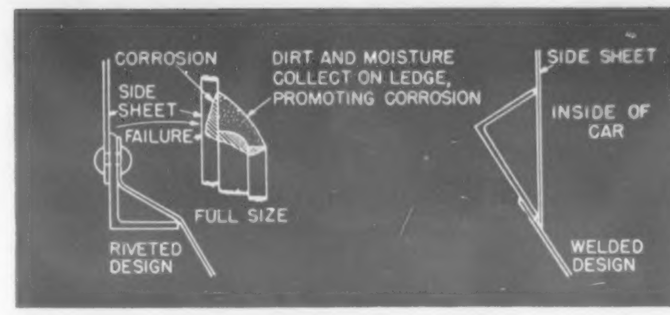
Under a given load, a structural member of high-strength steel will normally have greater deformation and deflection than a similar member of ordinary structural steel. Since the modulus of elasticity is essentially constant for all grades of steel, the deflections of beams of equal span and depth, and loaded similarly, will be proportional to the maximum stresses in the beams. In general, stress and not deformation or deflection is the criterion for design and the possible 50% increase in deflection will usually not be significant.

Where the deflection of beams is specifically limited it may be necessary to resort to one or all of the following methods for decreasing the deflection.

1. Decrease the bending moment by;
    a. Changing the distribution of the load.
    b. Introducing restraining moments at the ends of the span.
2. Decrease the span.
3. Increase the depth of the beam.

The life of many structures is definitely predicted upon the length of time elapsing before corrosion reduces the thickness of material to a point where failure occurs. As has been emphasized elsewhere, most of the high-strength steels possess superior resistance to atmospheric corrosion as compared to the ordinary grades of steel used for structural purposes. This added corrosion resistance of the high-strength steels is a valuable asset in maintaining the service life of the thinner high-strength steel sections. Similarly, where minimum weight is not of prime concern, the added corrosion resistance of these steels will, in most instances, greatly increase the service life of a structure.

The use of formed high-strength steel sections as structural members has gained wide acceptance in many industries. Such sections are made from plate, sheet and strip, and have been found especially advantageous in instances where rolled sections are not available in the de-



Recommended side sill construction of high-strength steel hopper cars to prevent formation of corrosion pockets.

sired size or form, nor in the reduced thickness need if full advantage is to be taken of the higher strength. Formed shapes give the designer an almost unlimited variety of "tailor-made" sections to fit his particular type of construction.

Welded construction is well suited to achieving the aim of weight reduction and the elimination of the causes of accelerated corrosion. Whereas all riveted construction requires the overlapping of material at joints, welded elements can be joined by butting the material together, with a consequent saving of material. With welded construction, it is also possible to eliminate ledges and pockets where dirt and moisture can accumulate and promote corrosion.

Every design benefits from a sound stress analysis. It is the fundamental basis for all design, and the more accurate an engineer's knowledge of the loads and stresses, the better is he able to effectively dispose of the material in the structure to resist loads. While many structures are difficult to analyze in detail, many of the modern experimental methods of analysis are furnishing much valuable information for the use of designing engineers. Structures of high-strength steel merit careful analysis and will be further improved as attention is paid to every detail of design and fabrication.

Applications

The desirable characteristics of the high-strength steels, provided at relatively low cost, make their use economical in nearly all of the major steel consuming industries. These steels are now employed to effect weight reduction, provide longer life, and reduce maintenance costs, because of their greater strength combined with superior corrosion resistance. Frequently the selection of high-strength steels is due also to the fact that they possess a combination of properties and desirable characteristics, already described, which are not available in other materials at a comparable cost.

Railroad Equipment

The earliest applications were made in railroad freight and passenger cars. Approximately one-half of the production of high-strength steels is still being shipped to man-

ufacturers of transportation equipment of many and various kinds. Other important consumers are the mining, construction, earth-moving, materials-handling, shipping, and machinery industries. Increasing quantities are being used in bridge and building construction.

Producers of high-strength steels have reported that more than 200,000 railroad freight cars have been built with bodies employing this type of material. Dead weight has been reduced as much as 5 tons per car. Experimental hopper cars have been built with body sheets and plates of only one-half the thickness used in conventional ordinary steel design; yet after 19 years of service, side and end sheets were still serviceable.

The Pennsylvania Railroad redesigned a series of automobile cars using high-strength welded construction instead of riveted carbon steel. The weight of the body structure was thereby reduced 9000 lb.

Since 1950 a trend toward the use in freight cars of high-strength steel in gages and sections equal to or heavier than those used in Association of American Railroads' standard designs, to provide long life with low maintenance costs, has been apparent, especially in hopper cars. Of the railroad passenger cars ordered by domestic road in 1951 and 1952, more than 66% were constructed largely of high strength steel. The average weight of such equipment is about 60 tons, whereas similar equipment built of carbon steel has previously weighed about 80 tons. In such equipment, the weight saving extended throughout the structure. The bodies were so lightened that it was possible to use four-wheel rather than six-wheel trucks.

Automotive and Agricultural Equipment

The automotive industry has made extensive use of high-strength steels in a variety of applications. Their superior properties are used to secure greater strength or weight reduction with no decrease in service life, in heavy trucks, trailers, and semi-trailers, gasoline truck tanks, garbage and refuse trucks, and in buses. One manufacturer of semi-trailers stated that the utilization of the high-strength steels resulted in 50% greater strength, longer life, and a weight reduction of approximately 950 lb in a single unit. A builder of van-type trailers and truck bodies said that the application of high-strength steels resulted in a weight saving of 25% to 40% and that this weight saving had resulted in reductions in the cost of power equipment, gasoline consumption, tires, license fees, and insurance. Passenger automobile uses include bumpers and some body parts. Steels of this type are more readily cold formed than other steels having comparable yield point and, therefore, are used for light, high-strength pressings.

In agricultural equipment, corrosion resistance is needed to provide long life under the abusive condition of exposure without protection. Furthermore, in most types of equipment, including those that are trailed, light weight is an economy. Manufacturers of farm appliances have used high-strength steels in combines, corn huskers, threshers, fertilizer spreaders, and farm wagons.

Materials-Handling Equipment

Materials-handling and earth-moving equipment utilize the strength, toughness and abrasion-resisting properties of high-strength compositions in power shovels, cranes, bulldozers, ditchers, graders, conveyors, and chutes. Power shovels provide one of the most striking examples of the advantage of weight reduction. A large electric shovel may weigh 1200 tons or more and have a boom 100 ft. long. In one design the boom and dipper stick were made of carbon steel and the dipper bucket of cast steel, with a capacity of 15 cu yd. When the builder had improved the design to eliminate weight in the boom, stick, and dipper by substituting welded high-strength steel, the shovel carried an enlarged dipper of 25 cu yd and the hourly capacity of the shovel was increased 76%.

Mine operators were among the first to recognize the advantage of using high-strength steel, and have now employed it in the bodies of many thousands of cars for handling coal, stone, and ore. The need for equipment that would provide exceptional sturdiness and long life led to the use of these steels in approximately the same sections as are used in similar cars built of carbon steel. Mine equipment in which these su-

Truss members, floor beams, stringers and pins on this 442-ft continuous through-truss bridge over the Willamette River at Eugene, Ore., are made of high-strength, low-alloy steel. The deadweight reduction permitted by its use—as high as 33 1/3 % in some tension members—resulted in a considerable saving in material as well as shipping cost.

perior steels are used to reduce weight and increase load-carrying capacity include skips, hoists, and, in some operations where grades are excessive, in car bodies. The abrasion and corrosion-resisting properties of high strength steels have influenced their adoption in hoppers, conveyors, and screens.

Construction Uses

Building construction does not generally provide a suitable field for high-strength steel because weight reduction in the structural members is not usually important or economical. However, where corrosion is a problem, these materials are used in both buildings and bridges. In some notable instances, particularly abroad, these steels have been used in buildings, bridges, and some other large structures fabricated at home for export and erection in distant countries, the principal objectives being reduced ocean freights and the economy of handling and erection charges at destination.

In bridges with relatively long spans, reductions in the weight of the structure itself made possible by using high-strength steel yields substantial economy of material. Engineers have found that the use of these steels is economical in the structural members of both large and small bridges. Satisfactory applications have also been made in deck or ballast plates of railway bridges, in blast plates and in highway bridges. One manufacturer of buildings has found that high-strength steel costs substantially less than carbon steel per pound of live load carried for roof purlins and side wall girts. By changing the purlin z-bars from carbon steel to high-strength steel of the same gage, the permissible roof load was increased 50% at minimum cost.

Numerous uses for the high-strength steels are found in machines used for building construction and road building such as concrete and asphalt mixers, graders, scrapers, and trailers for heavy loads. The user of a trailer rack 48 ft long built of high-strength steel stated that the pay load capacity was 40,000 lb with a deflection in the frame of not more than 1 in. under that load, and that operating economies would amount to as much as $25.00 per day. Oil well towers and transmission towers have also been made lighter without sacrifice of strength by applying the high-strength steels.

Ships

Weight reduction in ship structures has distinct advantages from an economic standpoint. Compared with a vessel of ordinary ship steel, lighter construction of the same strength and with adequate protection against corrosion requires less power for the same speed and pay load, increased speed for the same power and pay load, or increased pay load for the same power and speed. Some of the high-strength steels have been approved for both riveted and welded construction by the American Bureau of Shipping and Lloyd's Register, for use in hull construction. The reduction in sections allowed by the classification societies below those specified for conventional construction using ship steel depends on the specific application. In general, the range is from 10 to 15%. Which of the alternate advantages mentioned above is most important, depends upon the types of vessel, cargo, and conditions under which the ship operates.

Uses which are developing for high-strength steels now include the inner bottoms, and floors, tank sides, and hatch covers of ore boats; the hulls of small vessels; barges, and accessories, such as boiler breechings, air heaters, coal bunkers, and engine deck plates.

Miscellaneous Uses

Miscellaneous applications of high-strength steels are numerous and greatly diversified. A few, suggestive of the wide range of uses in which the special properties of these materials prove valuable are lampposts, automobile jacks, cable reels, stokers, and air-conditioning equipment. One alert chair manufacturer reduced the weight of bus seats by 20% or 30 lb per seat. This example is representative of many possible applications that are not immediately obvious.

Economics of Application of High-Strength Steels

The selection of high-strength steels in preference to other materials is usually based on one or more of three potential advantages: 1) minimum cost per unit of strength, 2) minimum cost per unit of service life, or 3) minimum overall cost due to operating savings and lower maintenance expense.

Cost per Unit of Strength

The first advantage is based on a high-strength-cost ratio. If the price per pound of high-strength steel is at a level of 1.50 times that of ordinary steel, the cost of tension members of these two steels of equal strength will be the same. Data have been presented elsewhere indicating that a cross-section of one square inch of carbon steel can be replaced by 0.66 sq in. of high-strength steel. The cost ratio at present is less than 1.50 for some brands and, therefore, the high-strength steel structures will, in certain cases, cost less than equivalent structures of carbon steel. In structures where the members are subjected to bending and compression, this weight ratio may not be so favorable to high-strength steel.

One other favorable cost factor is that transportation charges for high-strength steel may be lower because of the smaller tonnage of steel transported. In many applications high-strength steel has cost no more than the carbon steel displaced. Shop costs will be disregarded because elsewhere it has been shown that for various reasons they are approximately the same for both high-strength and carbon steels.

Cost per Unit of Service Life

The useful service life of many structures is determined by the corrosion resistance of the material from which they are constructed. This relates to the second advantage resulting from the use of high-strength steel — minimum cost per unit of service life. It has been shown that some high-strength steels possess atmospheric corrosion resistance 4 to 6 times that of carbon

steel, or 2 to 3 times that of copper steel. If the life of structures can be doubled by the adoption of a superior grade of steel costing but one-half more than the grade displaced, the economy of the substitution becomes obvious.

It should be pointed out that the material cost might be 50% higher, but that the overall cost of comparable structures would not differ so greatly because labor costs would be the same in either case and shipping costs lower for the high-strength steel. Moreover, if the life is increased only by one-half, or even somewhat less, the application will prove economical wherever labor costs are a factor of substantial importance when compared with material costs.

Saving in Operating Costs

The third advantage provided by the employment of high-strength steel over other material relates to operating savings, including lower maintenance expense, which accrue to the owner of the improved modern equipment. Due to the reduction in weight made possible by these steels, the resulting savings are often substantial in both mobile equipment and in machines of various types. Among the outstanding examples of such weight saving economies are modern light-weight designs of railroad freight cars, highway freight trailers and high capacity tank trucks, general service highway trucks, truck bodies, and so on. These vehicles have one characteristic in common: namely, the maximum loaded weight is limited by the capacity of the wheels or bearings. Hence, the income producing pay load is limited to the difference between the total load limit and the weight of the vehicle. Consequently a reduction in weight produces an equivalent increase in pay load that can be transported. Too, overloading of tires can be reduced with a resulting increase in tire life.

The maintenance expense of some of the mobile equipment which has now been operated nearly 20 years has been substantially lower than that of similar conventional equipment of carbon steel. It is too early to do more than anticipate that even larger savings will result in connection with the structures which now incorporate design and fabrication improvements to eliminate premature failures resulting from corrosion and abuse.

The value of weight reduction for these vehicles in different kinds of service has been calculated by various authorities. Prominent railroad officials have stated that the reduction of weight in an average freight car is worth 10¢ per lb. A study of tractor semi-trailer operations indicated that in inter-city hauls, a reduction in weight of the trailer unit of 1000 lb increased the annual profit approximately $450 per average unit. Under conditions in which the weight of the loaded vehicle approaches the maximum weight permitted on the highways of certain states, estimates of the value of weight saved approximate 50¢ per lb and higher. Under certain circumstances an increase in loading capacity is not the objective sought, but rather a decrease in the weight of the vehicle itself in order to come within the maximum weight allowed on the highways of certain states, or to bring the vehicle into a lower weight classification in order to economize on license fees. In one instance, such a weight reduction of the vehicle resulted in saving $125 in the cost of its operating license.

Increases in operating profits have likewise been obtained by using high-strength steel in earth-moving tractors, lift trucks, and numerous other types of material-handling equipment.

The reduction of weight in certain parts of various machines may effect spectacular increases in output as in the case of the excavating equipment cited previously. This is true also in respect to grab buckets, crane booms, mine cages and skips. The economic advantages resulting from increased pay load due to substantial reductions in dead weight have resulted in the widespread use of high-strength steel in such equipment.

The far reaching effects of weight reduction through modern design of light-weight construction have been mentioned and may be somewhat elaborated upon. It has been demonstrated that approximately 3 tons of high-strength steel are equivalent to at least 4 tons of carbon steel; thus, one-third more carbon steel would be required in many structures. Putting it another way, from an equal amount of high-strength steel, 25% more units of lighter weight and sometimes of greater capacity could be built. When steel production is inadequate to meet all demands, the additional units which can be produced by employing high-strength steel is an effective welcome means of meeting consumer demand.

The greater significance of this increased efficiency in the use of materials lies in its salutary effect upon our rapidly depleting national resources. For every ton of carbon steel consumption rendered unnecessary by the use of high-strength steels our natural resources are conserved by 1.8 tons of iron ore, 1.4 tons of dolomite, and 0.3 tons of purchased scrap and other materials—a total saving of raw materials out of all proportion to the small quantities of the alloying elements consumed in the manufacture of these superior steels.

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Materials Engineering File Facts

Conforming Specifications for Cast Copper Base Alloys

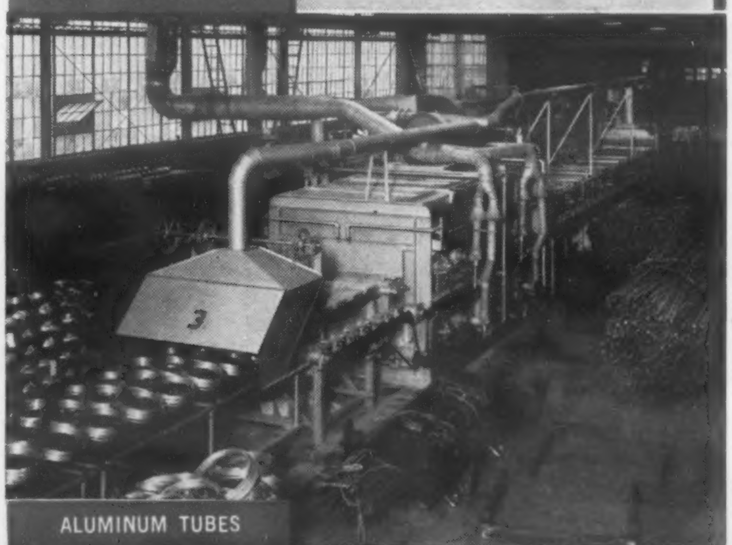
The following table is only a cross reference for the various organizations drawing up specifications, and should only be used as a guide. The original should be consulted for details.

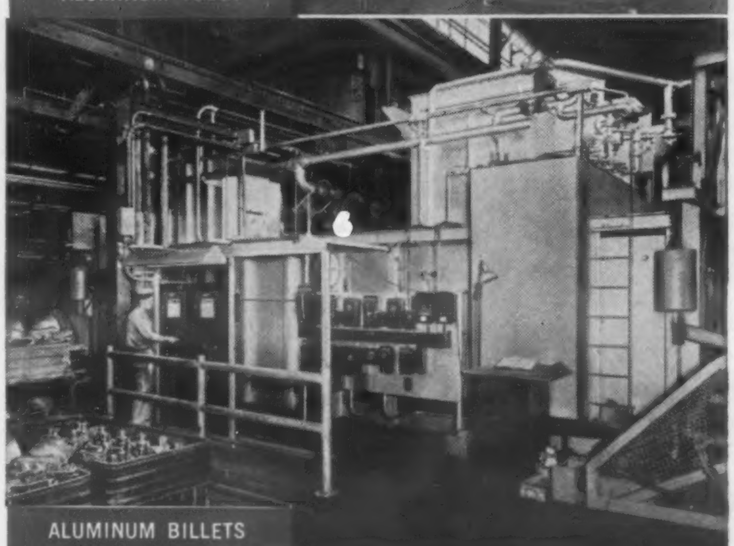
Class	Alloy	A.S.T.M. Spec.	A.S.T.M. No.	FEDERAL Spec.	FEDERAL Grade	NAVY Spec.	NAVY Grade	MILITARY Spec.	MILITARY Grade	SAE	AMS
Tin Bronze	88-10-0-2	B143-52	1A							62	4845D
		B30-49[1]	1A[1]								
		B22-52	D								
	88-8-0-4	B143-52	1B	QQ-B-691b	5	46M6i		MIL-M-16576		620	
		B30-49[1]	1B[1]	QQ-B-701a[1]	5[1]	46B25d[1]	III[1]				
	85-15	B22-52	B	QQ-B-691b	9	46B22g	III	MIL-B-16261	III		
				QQ-B-701a[1]	9[1]						
	81-19	B22-52	A	QQ-B-691b	10						7322A
				QQ-B-701a[1]	10						
	89-11									65	
Leaded Tin Bronze	88-6-2-4	B143-52	2A	QQ-B-691b	1	46B8i		MIL-B-16541		622	
		B30-49[1]	2A[1]	QQ-B-701a[1]	1[1]	46B25d[1]	I[1]				
		B61-52									
	87-8-1-4	B143-52	2B	QQ-B-691b	6 & 6x	46B5j	I & II	MIL-B-16540	A-B	621	
		B30-49[1]	2B[1]	QQ-B-701a[1]	6 & 6x[1]	46B25d[1]	IV[1]				
	87-10-1-2										4846A
	88-10-2-0									63	
	87-11-1-0-1									640	
High Lead Tin Bronze	80-10-10-	B144-52	3A							64	4842A
		B30-49[1]	3A[1]							792	4827B
		B22-52	C								
	83-7-7-3	B144-52	3B	QQ-B-691b	12	46B22g	VI	MIL-B-16261	VI	660	
		B30-49[1]	3B[1]	QQ-B-701a[1]	12[1]						
	85-5-9-1	B144-52	3C							66	
		B30-49[1]	3C[1]								
	78-7-15	B144-52	3D	QQ-B-691b	7	46B22g	IV	MIL-B-16261	IV		4825B
		B30-49[1]	3D[1]	QQ-B-701a[1]	7[1]						
		B66	HB								
	70-5-25	B144-52	3E			46B22g	V	MIL-B-16261	V		4840A
		B30-49[1]	3E[1]								
		B66	SB								
	84-8-8			QQ-B-691b	8	46B22g	II	MIL-B-16261	II		
				QQ-B-701a[1]	8[1]						
	71-13-16			QQ-B-701a[1]	13[1]	46B22g	VII	MIL-B-16261	VII		
	75-5-20	B66-B67	SB			46B22g	I	MIL-B-16261	I		
	81-8-11	B66	PB								
Leaded Red Brass	85-5-5-5	B145-52	4A	QQ-B-691b	2	46B23e		MIL-B-16444		40	4855B
		B30-49[1]	4A[1]	QQ-B-701a[1]	2[1]	46B25d[1]	II[1]				
		B62-52									
	83-4-6-7	B145-52	4B			46B5j	III	MIL-B-16540	C		
		B30-49[1]	4B[1]								
Leaded Semi-Red Brass	81-3-7-9	B145-52	5A	QQ-B-691b	4 & 11	46B24e					
		B30-49[1]	5A[1]	QQ-B-701a[1]	4 & 11[1]	46B5j	III	MIL-B-16540	C		
	76-3-6-15	B145-52	5B								
		B30-49[1]	5B[1]								
	80-5-2-13			QQ-B-691b	3	46B21d		MIL-B-16542			
				QQ-B-701a[1]	3[1]						

(Continued on page 139)

← For more information, Circle No. 496


BRASS SLABS AND STRIP


ALUMINUM TUBES


ALUMINUM BILLETS


BRASS BILLETS

costs trimmed quality assured

in tailor-made furnaces for non-ferrous metals

Whatever non-ferrous metals you heat treat—in whatever size or shape—'Surface' engineers can tailor furnaces to fit your production needs. Some of the many custom-built 'Surface' furnaces are shown here—others have been used for slab heating, annealing, stress relieving, solution heat treating, ageing, forging, homogenizing, precipitation hardening.

'Surface' furnace engineering is based on years of practical experience, intensive research in metallurgical heating methods, and an almost unlimited variety of furnace and conveyor equipment. 'Surface' engineers have worked with the processors of copper, aluminum, and magnesium alloys as well as precious metals; giving them the "right cut" in costs, increased production, improved quality. Write today for Literature Group H53-6, showing 'Surface' tailoring for heat treating non-ferrous metals and alloys.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

For more information, turn to Reader Service Card, Circle No. 329

Conforming Specifications for Cast Copper Base Alloys (Continued)

Class	Alloy	A.S.T.M. Spec.	A.S.T.M. No.	FEDERAL Spec.	FEDERAL Grade	NAVY Spec.	NAVY Grade	MILITARY Spec.	MILITARY Grade	SAE	AMS
Leaded Yellow Brass	71-1-3-25	B146-52	6A	QQ-B-621a	C	46B11h	II				
		B30-49[1]	6A[1]								
	67-1-3-29	B146-52	6B	QQ-B-621a	B	46B11h	I			41	
		B30-49[1]	6B[1]								
	63-1-1-35	B146-52	6C	QQ-B-621a	A	46B10h					
		B30-49[1]	6C[1]								
		B176-52	Z30A								
Manganese Bronze	60-20-15*	B147-52	7A	QQ-B-726c	D						
		B30-49[1]	7A[1]	QQ-B-731b[1]	D[1]						
		B132-52	A								
	65-25-20*	B147-52	8A	QQ-B-726c	A	49B3f		MIL-B-16443		43	4860A
		B30-49[1]	8A[1]	QQ-B-731b[1]	A[1]	46B25d[1]	V[1]				
	90-45-18*	B147-52	8B	QQ-B-726c	B	46B29a	b	MIL-B-16522	2	430A	
		B30-49[1]	8B[1]	QQ-B-731b[1]	B[1]	46B25d[1]	VII[1]				
	110-60-12*	B147-52	8C	QQ-B-726c	C	46B29a	a	MIL-B-16522	1	430B	4862B
		B30-49[1]	8C[1]	QQ-B-731b[1]	C[1]	46B25d[1]	VI[1]				
		B22-52	E								
Aluminum Bronze	Kramer "M"	B148-52	9A	QQ-B-671a	A	46B18d	1	MIL-B-16033	1	68A	
		B30-49[1]	9A[1]	QQ-B-675[1]	1[1]	46B19a**[1]					
	Kramer "I"	B148-52	9B	QQ-B-671a	B	46B18d	2	MIL-B-16033	2	68B	
		B30-49[1]	9B[1]	QQ-B-675[1]	2[1]						
	Kramer "L"	B148-52	9C	QQ-B-671a	C	46B18d	3	MIL-B-16033	3		4870B
	or "C"	B30-49[1]	9C[1]	QQ-B-675[1]	3[1]						4872A
	Kramer "N"	B148-52	9D	QQ-B-671a	D	46B18d	4	MIL-B-16033	4		
	or "R"	B30-49[1]	9D[1]	QQ-B-675[1]	4[1]			MIL-B-6947			
Nickel Silvers	12% Nickel	B149-52	10A								
		B30-49[1]	10A[1]								
	20% Nickel	B149-52	11A			46C12		MIL-C-17112			
		B30-49[1]	11A[1]								
	25% Nickel	B149-52	11B								
		B30-49[1]	11B[1]								
Silicon Bronze	1-5% Si	B198-52	12A	QQ-C-593		46B28a	b				
	5% Zn Max										
Silicon Brass	2½-4% Si***	B198-52	13A			46B28a	a				
	3-5% Si***	B198-52	13B			46B28a	a				
		B176-52	ZS144A								

NOTES:

* *Mechanical Properties of Manganese Bronzes; i.e., 60,000 psi Tensile Str; 20,000 psi Yield Str; 15% Elong*
** *46B19a Superseded by QQ-B-675-1.*
*** *12 to 16% Zinc.*
[1] *Specification are for ingot; others are for castings.*
The Military Specifications supersede Navy Specifications in column to the left.

Courtesy H. Kramer & Company

367% Longer Service

An example
of what you can
expect from

INCO
Castings

This "S"® Monel sand cast impeller served without trouble for 22 months, 367% *longer* than when other metal was used for impellers. "Coke breeze" (small broken-off coke particles) which mixes with circulating water during quenching operation did not wear down "S" Monel even though 1690 tons of coke per day were from incandescence to below burning point in this gas company installation. Impeller was replaced because other pump parts had worn out.

Whether you need a replacement part or a component for new equipment . . .

You can expect extra advantages when you order castings from Inco . . . in Inco Nickel Alloys.

Here's why.

Inco gives you any size casting in any practical shape, of any weight from ounces to tons. Even castings you previously thought impractical to produce in Monel®, Nickel or Inconel® can often be cast by Inco's specialists.

Inco gives you dependable high quality castings because they are made to meet or exceed government specifications.

And you get the benefit of Inco's help in solving your metal problem based on wide experience in field and laboratory testing of the Nickel Alloys.

So when you need a sand or centrifugal casting to withstand destructive service conditions, think of Nickel Alloys. Every one is the product of Inco research, especially developed to withstand the rigors of corrosion, abrasion, erosion and galling. And when you think of Nickel Alloy castings, think of Inco's own foundry . . . your outstanding source of supply.

To get a good idea of how you can benefit from using "S" Monel, write for "Engineering Properties of Cast "S" Monel."

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

Inco Castings *SAND, CENTRIFUGAL, PRECISION*

For more information, turn to Reader Service Card, Circle No. 416

Materials Engineering File Facts

MATERIALS & METHODS
February • 1954
Number 270

Materials Data Sheet

Cast Phenolic Resins

Cast phenolic resins are thermosetting. Parts are produced by pouring the resin into a mold and baking. Large intricate castings can be produced. The production schedule is flexible and cast phenolics are especially suitable for use where design changes are frequent.

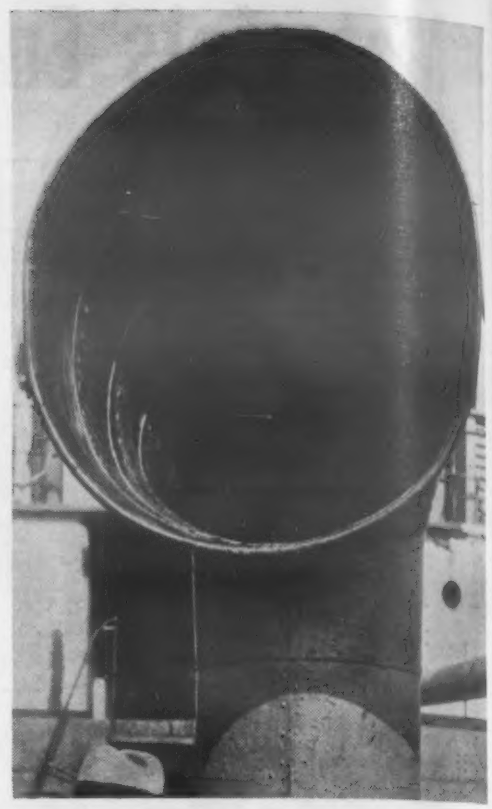
Type	ASTM Test Method	Mechanical and Chemical Type I	General Purpose Decorative Type II	General Purpose Transparent Type III
PHYSICAL PROPERTIES				
Specific Gravity	D792	1.31	1.32	1.33
Coeff of Exp per F	D696	3.3–4.4 x 10^{-5}	3.3–5.5 x 10^{-5}	4.7–6.6 x 10^{-5}
Water Absorption, 24 hr %	D570	0.35–0.40	0.32–0.35	0.3–2.0
Flammability (over 0.050 in.) in./min	D635	Self extinguishing		
MECHANICAL PROPERTIES				
Mod of Elast in Tension, Psi	D638	4–5 x 10^{5}	3–4.5 x 10^{5}	1–3 x 10^{5}
Tensile Str, Psi	D638	6000–9000	5000–7200	2500–4500
Hardness, Rockwell	D785	M93–M120	M90–M105	R98–R120
Impact Str, Izod Notched (Ft-lb per in. of notch)	D256	0.25–0.40	0.30–0.45	0.23–0.35
Mod of Elast in Flexure, Psi	D790	3–5 x 10^{8}	3–5 x 10^{5}	1–3 x 10^{5}
Flexural Str, Psi	D790	11,000–17,000	10,000–15,000	4,000–7,000
Compressive Yld Str (1% offset), Psi	D695	14,500–18,000	12,800–15,800	4,500–6,500
ELECTRICAL PROPERTIES				
Elect Res, Ohm-Cm (Volume)	D257	1–7 x 10^{12}	1–3 x 10^{12}	3 x 10^{11}
Dielectric Str (Short Time), Volts/Mil	D149	350–400	300–450	75–250
Dielectric Constant				
60 cycles	D150	6.5–7.5	15–20	20–30
1,000,000 cycles	D150	4.0–5.5	5.0–11.0	7–8
Loss Factor				
60 cycles	D150	0.05–0.9	0.4–4.0	5.0–17.0
1,000,000 cycles	D150	0.15–0.35	0.05–1.10	0.6–0.8
FABRICATING PROPERTIES		Castings produced by pouring resins into molds which are generally made from lead. Resins converted to solid product by heating for several days, at atmospheric pressure and at temperatures below 212 F. After oven baking, casting is removed from mold, and is ready for machining and polishing.		
CORROSION RESISTANCE		Unless specially formulated, not resistant to strong alkalies or strong acids; dilute alkalies, slight to marked attack depending on alkali; dilute acids, no effect or slight decomposition depending on acid; continuous immersion in acetone, cellosolve, melthyl alcohol, ethyl alcohol shows noticeable attack depending on time, temperature and hardness of product.		
USES		Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts; furniture hardware; instrument casings; sporting goods; costume and ornamental jewelry.		

Prepared with the assistance of the Manufacturing Chemists' Association, Inc.
Based on the Chemists' Association publication "Technical Data on Plastics," 1952

Correction

The File Fact appearing in January, starting on page 129, was numbered incorrectly. It should have been Number 268, not 266.

Industrial asphalt emulsions coatings show superior performance under extreme conditions of exposure.



Asphalt protective coating is especially serviceable as a coating for galvanized metal such as inside of this ship's hold ventilator.

Where Asphalt Coatings

● ASPHALT AS a protective coating has come a long way since the Egyptians used it to preserve mummies. The nature of asphalt hasn't changed much since then, but modern industry has refined it and found scores of practical uses for it.

Today asphalt is used in manufacturing pavements, roofing, flooring, saturated fabrics, coated papers, impregnated box boards, sizings and adhesives. It is used as compounds in paints, sealers, laminating adhesives and vapor barriers. Its direct application to metal and metal structures provides an excellent protective coating against rust and corrosion.

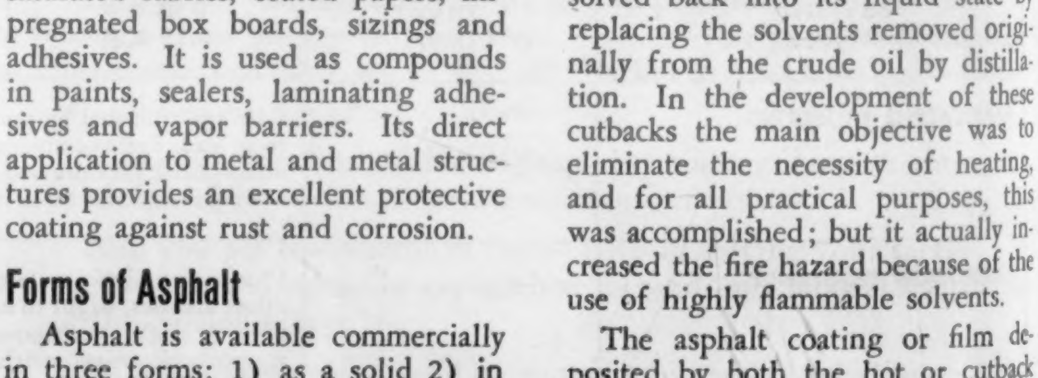
Forms of Asphalt

Asphalt is available commercially in three forms: 1) as a solid 2) in the form of solutions 3) in the form of dispersions or emulsions.

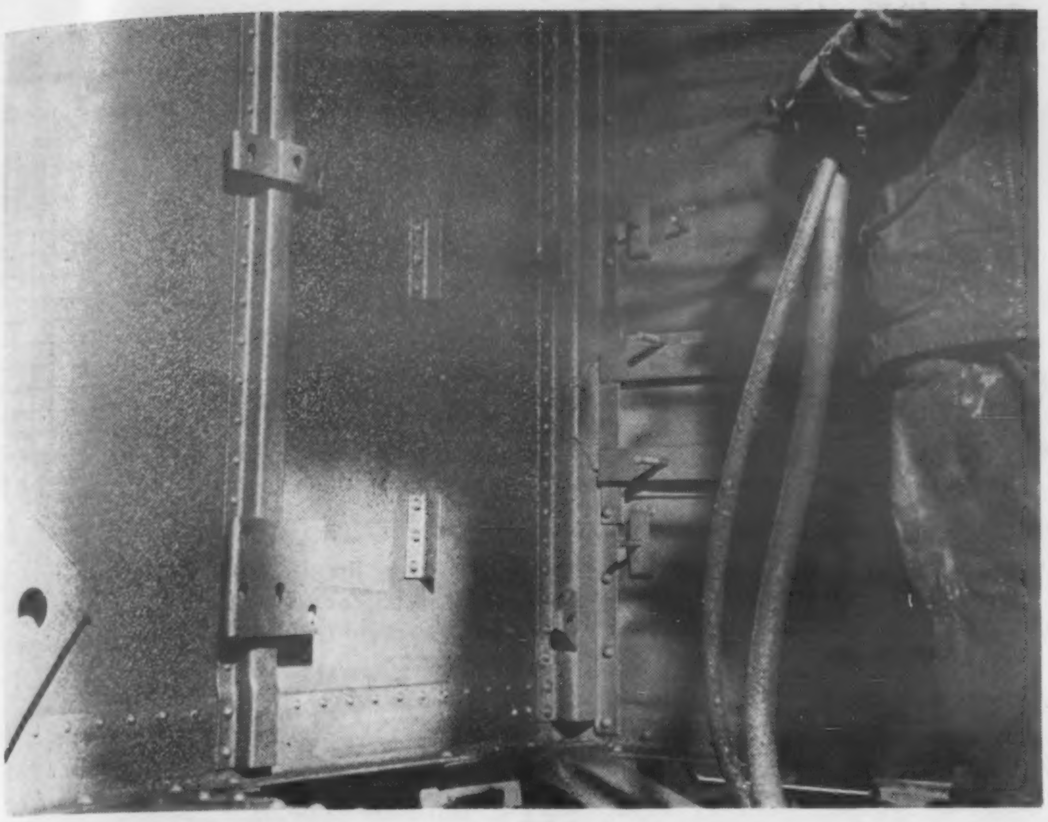
In its natural or solid state, asphalt requires heating to a temperature above its melt point to render it fluid for application. This is the original and oldest method of using asphalt and it has many obvious shortcomings.

Asphalt in the form of solution is called a "cutback" asphalt, the term derived from the fact that it is dissolved back into its liquid state by replacing the solvents removed originally from the crude oil by distillation. In the development of these cutbacks the main objective was to eliminate the necessity of heating, and for all practical purposes, this was accomplished; but it actually increased the fire hazard because of the use of highly flammable solvents.

The asphalt coating or film deposited by both the hot or cutback methods, while superior in weatherability to many non-asphaltic coatings, nevertheless undergoes deteri-



Ordinary types of asphalt coatings crack or otherwise deteriorate when exposed to elements.



Asphalt emulsion coating sprayed on inside steel box cars prevents rusting and corrosion.

Are Used

by GALE BENN, Flintkote Co.

oration when exposed to the elements. The process begins by the oxidation of the surface molecules which are exposed to the sun's rays. Then internal flow causes fresh molecules to rise to the surface displacing the oxidized molecules, so that by degrees the entire film is ultimately oxidized. On prolonged exposure, films of this type sag, run, and develop the familiar crazing or alligatoring.

Emulsion of asphalt, reduced to its simplest terms, means the breaking up mechanically of asphalt into minute particles and the dispersing of these particles in water. There are two main types of emulsions. The first is generally referred to as soap emulsion because a soap is used as the emulsifier. When used as a protective coating the dried film of a soap emulsion will tend to soften under heat, crack at cold temperatures and oxidize when exposed to the weather in much the same manner as hot or cutback asphalts.

The second class of emulsions has been termed industrial asphalt emulsions. These are characterized as stable or clay type. Their composition involves an "outer phase" which is water, and "inner phase" which is asphalt and an emulsifying agent which is a prescribed type of mineral colloid. The latter gives these emulsions the descriptive name clay type.

Unlike hot or cutback asphalts and soap type asphalt emulsions, the dried film of clay type asphalt emulsions will not flow under heat, crack in cold temperatures or progressively oxidize from internal molecular flow when exposed to sun and weather. The term efficiency of these as protective coatings is in almost direct proportion to the thickness of film applied; that is, as the thickness is increased the effective life in years increases at approximately the same rate.

Corrosion Resistance

Asphalt emulsions show superior performance under extreme conditions of exposure. They are recommended for long term resistance to weather, and corrosive elements such as dampness and mild concentrations of acids and alkalies.

In 1937, for example, a large oil company used an asphalt emulsion mixed with copper oxides as an anti-fouling protection on lighters. It was found after six months that the edhesion of sea growths was far less than when ordinary marine paints were used. It was found also that aside from the anti-fouling properties, the anti-corrosive properties of this application were in excellent condition.

(Continued on page 144)

continued from page 143

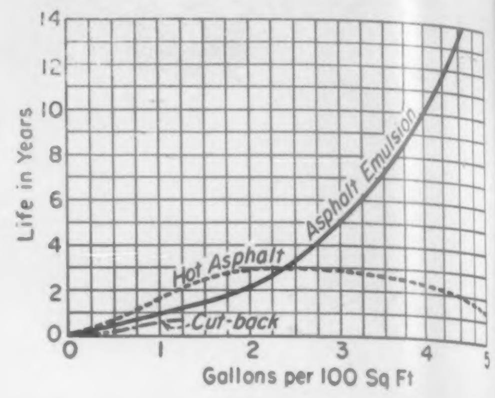
Water screens, as another example, at the entrance to the cooling water conduit of a large power station were treated with an asphalt emulsion in 1943. The screens are located at an angle of 60 deg to the horizontal to remove debris and foreign matter from the river water entering the conduit. Corrosion of the screens would be accelerated because the frame is steel, the mesh in the screen is bronze, and rivets and bolts either bronze or galvanized. Turbulent water moves continuously through the screens, exposing them to a high percentage of oxygen.

After five years, the conditions of this application were good except for some rust on the bolt heads. The engineers felt, however, that it could be left untouched for another year and that the results obtained were superior to those of any treatment previously employed.

Insulation Protection

The use of insulation pays big dividends, not only in fuel or power savings, but also in the improved products which are made possible by accurate temperature control. Insulation pays its cost many times over. But it must be protected from moisture and weather since large losses are suffered when breaks in the insulation or in the coating occur. These destroy insulating value and often the insulation itself. Consequently a protective coating of high durability is of paramount importance.

Asphalt clay-type emulsions fibrated with asbestos are specifically designed for use as trowel-applied protective coatings over thermal insulation materials. They provide excellent durability under extreme weather conditions; will not sag or flow at temperatures up to 500 F, or develop cracks in cold or under expansion or contraction of the base due to changes in temperatures. Elasticity adapts them as effective coatings for both flexible and rigid types of insulation materials, blankets, boards and blocks. They will not support combustion nor are they toxic. They are perfectly safe for application in en-



Average life in years in relation to film thickness, obtained from straight coatings of asphalt in hot, cutback and emulsified form when exposed to the weather.

closed or confined places without hazard to workmen, and do not transmit odor.

Some insulation is furnished with wire mesh over which insulating cements or protective coating is applied. It is more common practice, however, for heavy insulation to be installed with a wrapping of wire mesh to hold it firmly in place. This wire further serves to prevent flaking of the insulation material and also to anchor the coating. It is essential in all cases that the insulating material be held tightly so that vibration, expansion or contraction will not crack it or rupture the protecting cement or coating.

Where block insulation is used, the surface is usually finished with a type of insulation cement as dictated by the temperature requirement. This material seals the joints between blocks, fills spaces where the use of blocks is impractical and provides a smooth surface. Asphalt emulsion coating is applied directly over this surface to protect it from moisture.

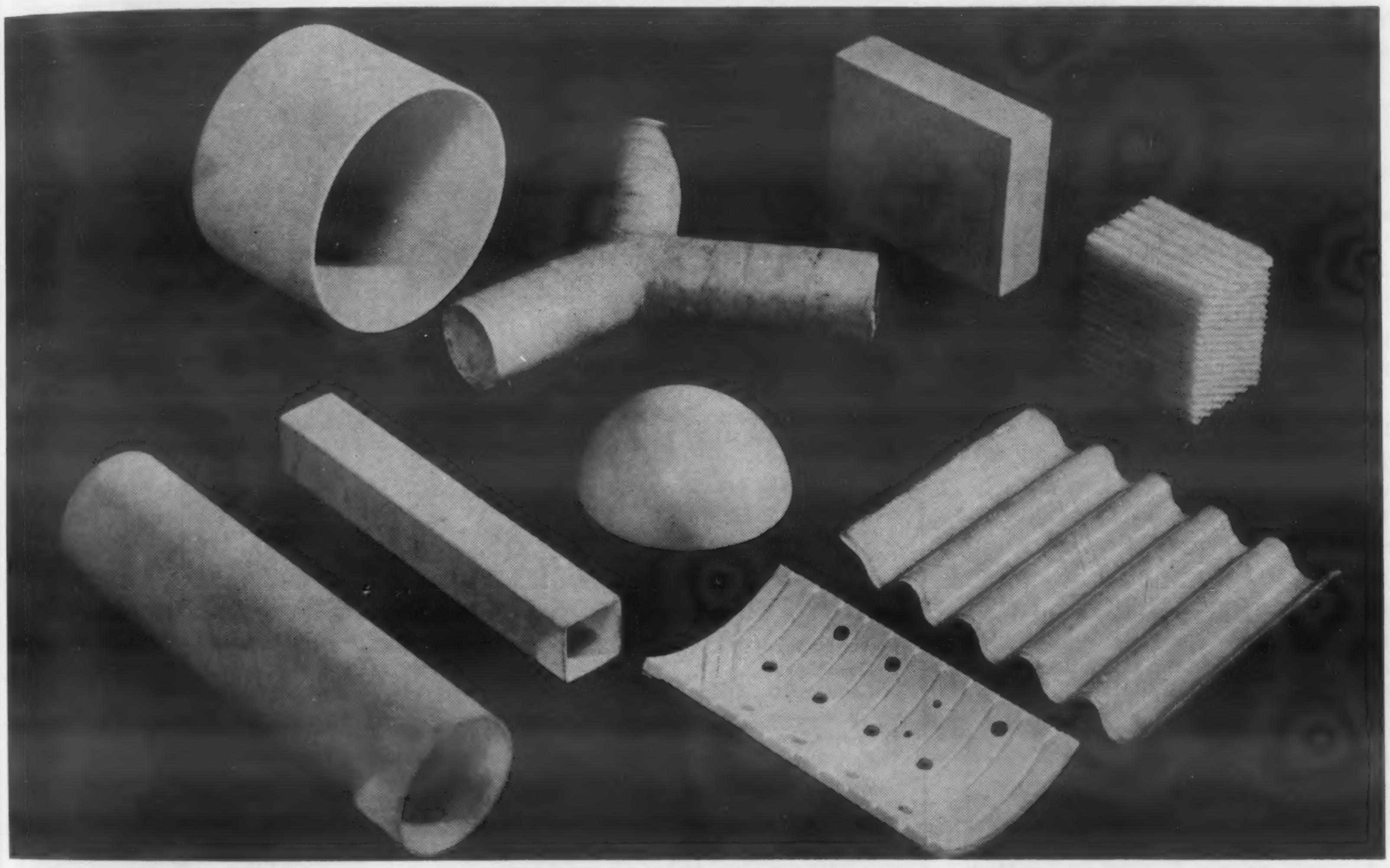
The two big advantages of using asphalt emulsion protective coatings are: 1) the low initial cost of application compared to other types of coatings, and 2) the extremely long life of the material which eliminates maintenance costs and the necessity of painting and repainting. And the one big disadvantage of this material, the dull black appearance of structures coated with asphalt, has been eliminated by the use of asphalt base aluminum paint.

Correction

The heading at bottom of page 198 in the article "High Alloy Castings in Heat Treating Equipment", December 1953 issue, was in error. The heading, which referred to strength and corrosion resistance of Alloy Types HT, HU, HW, and HX, should have read "Excellent Strength and Corrosion Resistance".

New Materials, Parts and Finishes

. . . and Related Equipment



These parts, laminated with the new silicone resin, possess high strength at elevated temperatures.

New Silicone Laminating Resin Offers

• Increased Strength
• Faster Cure

A new silicone low pressure laminating resin has been developed by *Dow Corning Corp.*, Midland, Mich., offering greater physical strength at room and elevated temperatures and providing a faster cure time.

A typical 1/8-in. low pressure laminate made with 181 glass cloth bonded with the Dow Corning 2106 Resin (30% resin) displays a flexual strength of 50,000 psi at room temperature and a tensile strength of 40,000 psi. After 48 hr cure the flexual strength at 500 F is 18,000 to 20,000 psi, while the tensile strength is 30,000 psi.

According to the company, the new resin is heat-stable, water repellent, inert, and resistant to oxidation and to the effects of most of the commonly used inorganic reagents. Though when used in laminates made up of inorganic fabrics the resin meets the requirements of Class H insulation, as defined in AIEE Standards No. 1, it is not recommended for use where dielectric properties are more important than physical, since there are other resins which are better for this purpose.

The properties of the resin suggest its use in fabricating various simple, irregular, or tubular aeronautical and

New Materials, Parts and Finishes

industrial structural parts which must have high strength at elevated temperatures. It is also useful in making dielectric parts for applications where high strength is essential.

The resin is supplied at 60% solids in toluene, at a viscosity of 30 to 50 ctp. If necessary it can be thinned with toluene. The resin is said to have good flow characteristics and, uncatalyzed, has a gel time of 5 to 10 min at 482 F. Dow Corning Catalyst XY-15, in proper quantity, is shipped with each order.

Laminating Procedure

The fabric to be laminated can be impregnated by conventional methods. Only glass cloth that has been properly desized either by heat cleaning or washing should be used.

For impregnated cloth to be used in low pressure laminating, the recommended procedure is 5 min. at 230 F. The precured cloth has a shelf life of several weeks if stored at a temperature below 80 F. Low pressure laminates can be made at a pressure in the range of 30 psi. Laminates less than 1/2 in. thick should be press cured at laminating pressures for 1/2 hr at 340 F; for 1/2 in. thick or more, 1 to 3 hr at 340 F. Some laminates may then be removed while still hot though this depends upon the thickness of the part and the laminating conditions used.

Recommended aftercure is gradually heating to 482 F in an air circulating oven and holding at that temperature for at least 6 hr. Longer cures will further improve the high temperature physical properties of the laminate.

Typical Properties of 1/8-in. Laminates of Type 181 Heat Cleaned Glass Cloth Bonded with 2106 Resin (35% Resin)

	Cured 48 Hr at 482 F	Aged Additional 200 Hr at 482 F
Specific Gravity	1.93	
Water Absorption, %	0.09	0.13
Flexural Strength, Psi: at 77 F	50,000	46,000
at 500 F	18,300	20,500
Flexural Mod of Elast, 10^6 psi: at 77 F	2.88	2.89
at 500 F	2.16	
Tensile Strength, Psi: at 77 F	40,600	
at 500 F	30,700	
Tensile Mod of Elast, 10^6 psi: at 77 F	2.74	
at 500 F	2.86	
Bond Strength, Lb at 77 F	1,020	
Compressive Strength, Psi at 77 F	21,300	
Compr Mod of Elast, 10^6 psi at 77 F	1.68	
Barcol Hardness, At 77 F	73	
Thermal Coefficient of Expansion	6.06×10^{-6}	
Arc Resistance, Sec	244	253
Dielectric Strength, V/m	100	100
Power Factor, 10^5 Cycles		
Condition A	0.0019	0.0019
Condition D 24/25	0.0075	0.0064
Dielectric Constant, 10^5 Cycles		
Condition A	4.03	4.07
Condition D 24/25	4.12	4.08
Surface Resistivity, Ohms		
Condition A	1.57×10^{13}	1.57×10^{13}
Condition D 96/25/96	0.15×10^{13}	0.20×10^{13}
Volume Resistivity, Ohm cm		
Condition A	2.43×10^{13}	2.43×10^{13}
Condition D 96/25/96	2.43×10^{13}	2.43×10^{13}

NOTE: Conditioning—A—As received.
D 24/25—Water Immersion 24 hours at 25 deg C.
D 96/25/96—96 hours at 25 deg C and 96% Relative Humidity.

Magnet Wire Insulated With Teflon

Magnet wire in a wide range of sizes and insulated with Teflon has been marketed for Class H service or better by *Hitemp Wires, Inc.*, 26 Windsor Rd., Mineola, L. I.

The insulated wire is said to have a low loss factor, a dielectric constant of 2.0 to 2.05 from 60 cycles per sec to 30,000 mc, and a high dielectric strength. Characteristics remain stable at temperatures ranging from —150 to 500 F, the insulation is non-flammable and inert to moisture and commercial solvents and chemicals.

The solid conductor may be either soft or annealed copper, on which the Teflon is dip-coated. Sizes range from 14 to 50 AWG, in six colors, and single, heavy, triple or quad thicknesses are available.

The company recommends their wire for high temperature and high frequency applications where miniaturization is a design factor, or where chemicals or solvents are encountered.

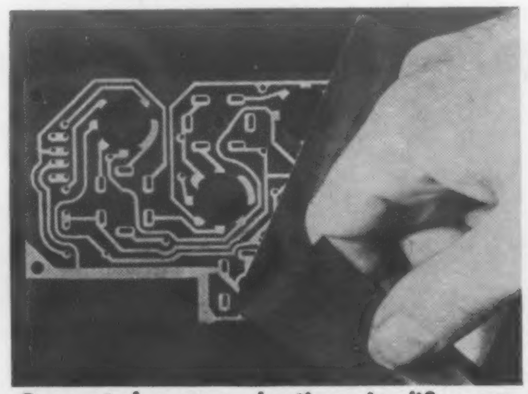
The manufacturer will also insulate special alloy wires to user specifications.

Copper-Adhesive Sheet Aids Printed Circuit Manufacture

Anaconda electrolytic sheet copper, cut to size, is now being supplied pre-coated with a new adhesive which is said to offer bond strengths on copper-to-thermosetting plastic sheets of 35 lb per in.

With the use of their new adhesive, R&A "plymaster", the *Rubber & Asbestos Corp.*, 225 Belleville Ave., Bloomfield, N. J., is producing these "adhesive - clad - copper" sheets for use in printed circuits for radio and electronic components. According to the company, production savings up to 75% are possible as compared with conventional methods.

The adhesive is available in two basic formulations: Type "N" for adhering copper sheet to phenolic resin base to pass the 392 F "solder dip test"; and Type "E" for the 450 F "solder dip test", and for use also with epon or silicone base laminates. Both formulations may be obtained pre-coated on either 1 or 2 oz electrolytic copper sheet.



Pre-coated copper sheeting simplifies production of printed circuits.

Plastics for Microwave Applications

A series of plastic materials of varying dielectric constants is now available from *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass., in sheet and rod form.

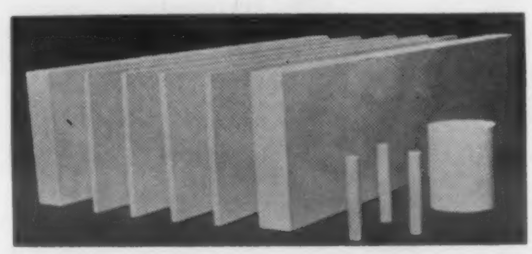
Called Stycast Hi-K, the stock materials possess dielectric constants of 3, 4, 5, 6, 7, or 8, in rod dia of 1, 2, and 3 in., and sheets of ½ and 1 in. thickness. Supplies of the material with other dielectric constants and other rod and sheet sizes are available on special order.

The materials have a maximum variation in dielectric constant of ±0.15 from 10^6 to 10^{10} cycles, while the dissipation factor is said to be below 0.001. The volume resistivity is greater than 10^{14} ohm-cm^3 and the dielectric strength is said to be greater than 500 v per mil.

The average physical properties of the materials are as follows:

Specific gravity	1.3
Tensile strength, Psi	8000
Flexural strength, Psi	13,000
Modulus of elasticity, Psi	2×10^5
Izod impact, Ft lb/in. of notch	0.3
Coefficient of Linear Expansion, Per deg F	27.8×10^{-6}
Water absorption, @ 77 F for 24 hr	0.1%
Temperature range	—94 to 255

Machinability is said to be excellent with carbide tools.



The new plastic material is available in sheet or rod form, in varying dimensions.

Tape Protects Bi-Metallic Joints

A tape designed to protect joints of dissimilar metals from galvanic corrosion has been developed by *Winn & Coales Ltd.*, Denso House, Chapel Rd., London, S.E. 27, England.

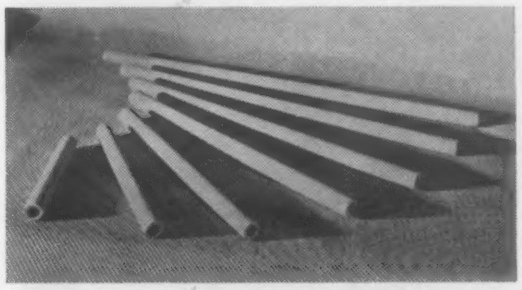
Due to the difference in potentials of many metals, galvanic corrosion is a hazard which must be taken into consideration when these metals are directly joined. Although the difference in potential between aluminum and structural steel is only small, aluminum alloys are electropositive to steel and direct contact, in the presence of moisture must be avoided. According to the company, Densochrome Tape provides the corrosion protection necessary for all bi-metallic joints in which aluminum is one of the metals used.

The tape consists of an open weave 100% absorbent fabric, fully impregnated and coated on both sides. The impregnant is made up of saturated petroleum hydrocarbons, technically free from acids, alkalis, waxes, resins, saponifiable and other deleterious matter. The fillers used are finely ground inert magnesium, aluminum and other silicates, said to be free from limestone, chalk, whiting and other calciferous matter. The compound contains 20% by weight metallic chromate inhibitor.

The tape has an electrical resistivity of 1×10^4 megohms per cm^2, an electric strength of 5500 v a.c. per single thickness of tape, and a tensile strength of 35 lb per in. of width. According to the company the temperature range of application is 0 to 130 F, though ambient temperatures of —50 to 130 F will not affect the protective qualities.

It is supplied in an average thickness of 0.045 in. and widths in multiples of 1 in. up to 33 in. In addition to being non-cracking, non-hardening, unaffected by vibration, and resistant to all mineral acids, alkalies and salts, the tape is also said to have a high degree of impermeability to water.

Glass-Based Enamel Protects Metal



Enamel protects iron and steel from corrosive attack in processing industries.

A glass-based porcelain enamel coating has been developed to protect iron and steel equipment exposed to corrosive chemical attack by liquids and gases at temperatures ranging up to 1400 F.

Developed specifically for use in aluminum and aluminum alloy baths, the enamel is said to hold promise for other industries such as those processing chemicals, zinc, lead, and magnesium. Research scientists from *Battelle Institute* and *Barrows Porcelain Enamel Co.*, Cincinnati, worked together in developing this material which is said to increase the service life of iron or steel parts in molten aluminum, and to provide more protection than existing porcelain enamels in this type of application.

Electrical Parts Cleaner Offers Safety Factor

A cleaner for electrical elements, designed primarily for personnel safety and comfort has been produced by the *Yosemite Chemical Co.*, 1040 Mariposa St., San Francisco 7.

A volatile, non-chlorinated nonconductive liquid, EPC 226 is said to be more effective than most chlorinated type materials in cleaning motor and generator windings, collector rings, brushes and casings, and switch gear panels, switch boards, coils and contacts. It has a Maximum Allowable Concentration rating in the same class as Stoddard Solvent; however, its flash point is higher throughout the evaporation cycle, the company claims.

EPC 226 will not discolor or corrode metals and will not attack Glyptol and black air-dry varnish during normal exposure time. The evaporation rate is said to be not so fast as to lead to moisture condensation and redeposition of soil, nor so slow as to cause inconvenience in drying by air blowing, and it leaves no residue upon evaporation.

The manufacturer recommends application with a non-atomizing type nozzle under a controlled air pressure of from 25 to 30 psi.

Phosphor Bronze Wire for Inert-Gas Welding

A phosphor bronze (Grade A) bare, coiled wire has been marketed for use with the inert-gas consumable electrode welding process by *Ampco Metal, Inc.*, 1745 S. 38th St., Milwaukee 46.

According to the company, the primary use for Phos-Trode is for overlay applications since it is said to be a soft bearing alloy; however, it can also be used for joining brasses, tin bronzes, cast iron, etc.

It can be used with Aircomatic, Linde Sigma and G-E filler-arc equipment. The wire is available in 0.045, 1/16, 5/64, and 3/32-in. dia sizes, layer wound on spools or rims in 25 lb standard packages.

Activator for Cold Rubber Formulations Now Available

Experimental quantities of phenylcyclohexyl hydroperoxide, which is said to have shown excellent results as an activator for GR-S cold rubber formulations, are now available from the *Phosphate Div., Monsanto Chemical Co.*, St. Louis 4, Mo.

According to the company, the new product, which is a yellowish liquid, also may be good as a polymerization catalyst for other applications such as styrenated polyesters. Recent tests have produced polymerization recipies for preparation of the cold GR-S rubber in less than 20 min at 41 F.

An active organic hydroperoxide, the substance is a 20% solution of phenylcyclohexane hydroperoxide in phenylcyclohexane.

(Continued on page 152)

for Greater Strength with Lighter Weight

in modern material handling equipment

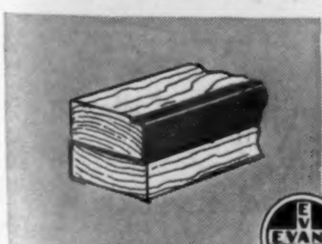
The increasing use of the Evans DF Loader reflects the progress of railroads toward more efficient material handling methods.

In the DF Loader there is high strength with minimum weight through the use of N-A-X HIGH-TENSILE steel. This low-alloy steel has 50% greater strength than mild carbon steel, with greater resistance to corrosion with either painted or unpainted surfaces.

You can get the same results as Evans. Your product can be made stronger, lighter in weight and longer-lasting, when you specify N-A-X HIGH-TENSILE steel.

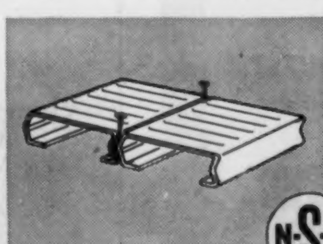
N·A·X HIGH-TENSILE STEEL

THE EVANS DF LOADER is a product of Evans Products Co., Plymouth, Mich. DF means Damage - Free, Dunnage - Free.



EVANS

NAILABLE STEEL FLOORING for boxcars, flatcars and gondolas is made of N-A-X HIGH-TENSILE steel, and is a product of Steel Floor Division, Great Lakes Steel Corporation.



N·S·F

Engineering data on these products available upon request to the manufacturers.

The "Wonder Bar," a section of which is shown at left, is a vital part of the Evans DF Loader. It is a wooden bar reinforced by a Z-bar made of N-A-X HIGH-TENSILE.

The "Wonder Bar," when locked into place, secures all kinds of lading. It is strong enough to resist shifting load stresses in moving boxcars, yet so light that one man can lift it into position. The DF Loader provides real operating economies for both railroads and shippers.

Another modern product for efficient transportation equipment is Nailable Steel Flooring, also made of N-A-X HIGH-TENSILE steel.

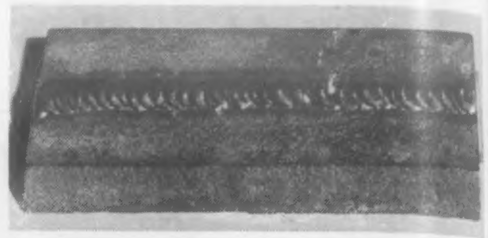
GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division **Ecorse, Detroit 29, Mich.**

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service Card, Circle No. 395

New Materials, Parts and Finishes



Electrode Welds Cold Cast Iron

A new electrode for welding cast iron without preheating has been marketed by the *Eutectic Welding Alloys Corp.*, 40-40 172 St., Flushing, New York. Called Xyron 2-24, this 3/32 electrode is said to operate on 35 to 75 amps and to provide dense, high tensile, machinable deposits without spatter.

According to the company, all-position welding is possible and repairs may be made in position without dismantling or special preparation. The electrode may be used for building up, repairing breaks or cracks, fabricating or for other cast iron applications.

New Process Offers Speedy Black Plating

A black plating process developed by the *Enequist Chemical Co., Inc.*, 100 Varick Ave., Brooklyn 37, is said to require only 3 to 4 min plating at 1 v, and 10 amps per 100 gal of solution.

According to the company, Electro-Black provides a black plate on practically all metals with the exception of aluminum. On die cast parts a thin copper or brass undercoat will suffice, and the plate will reflect the surface underneath without additional polishing or processing.

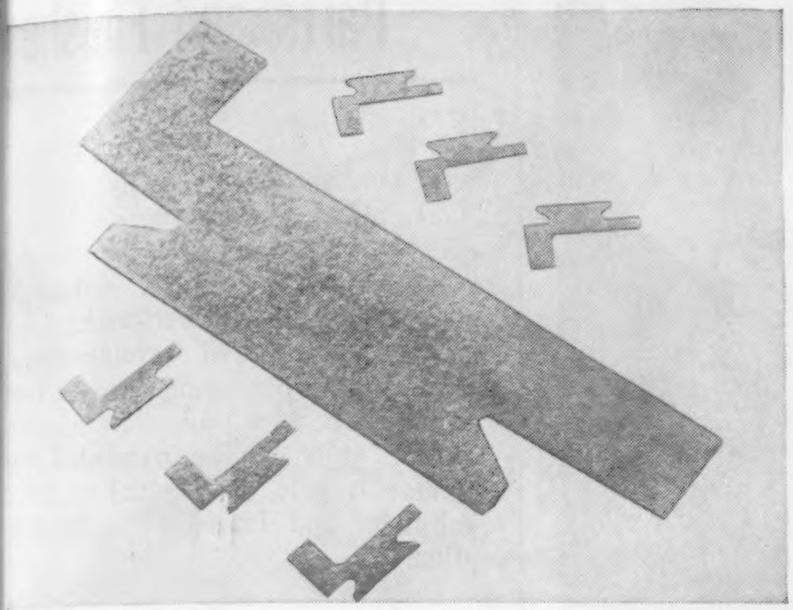
The bath is operated at 150 F in a steel tank utilizing stainless steel or copper anodes.

Sigma Rectifier Type Welder

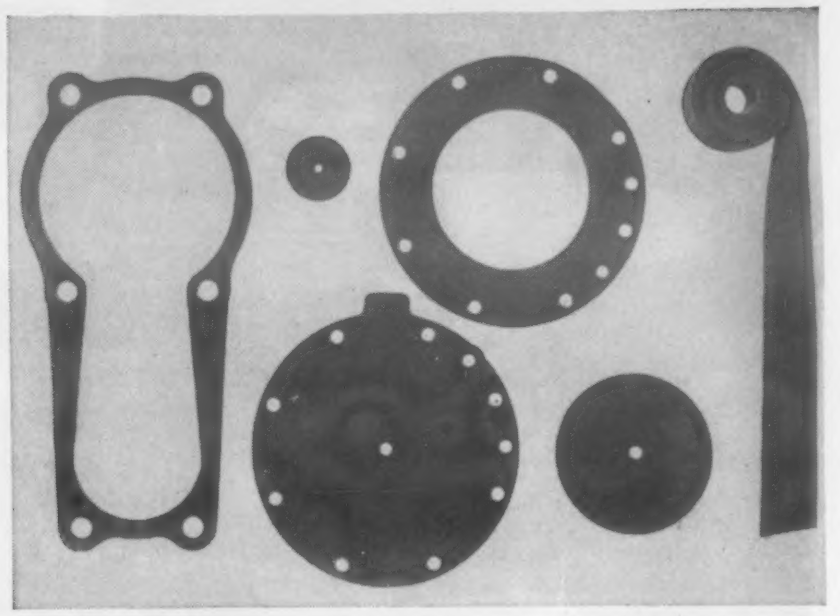
A rectifier type 500 amp 100% duty cycle welder which is said to maintain stable welding conditions regardless of arc variations has been marketed by *Miller Electric Mfg. Co.*, Appleton, Wis.

(Continued on page 154)

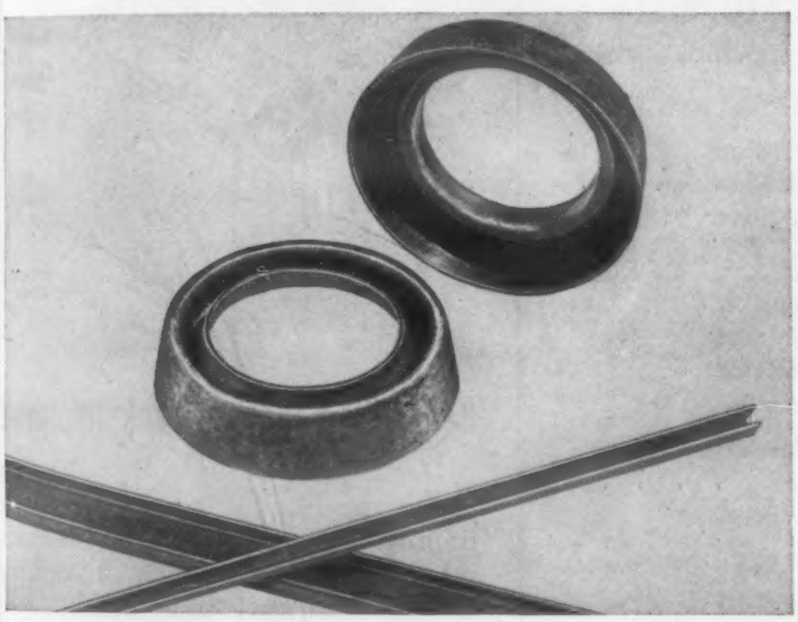
Do *you* have Class H insulation problems?



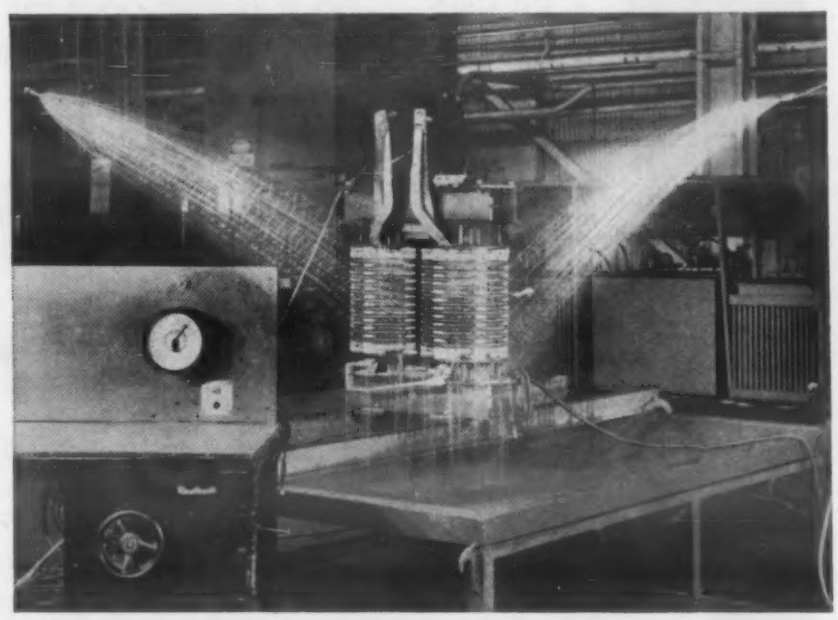
1. **Need a Class H segment plate that's easy to work with?** ISOMICA* Segment Plate—made of built-up continuous mica sheet—shows no tendency to split or flake. Small segments of heavy thickness may be punched, and larger segments can be accurately sawed, milled, punched, etc.



2. **Need rubber-like properties for long periods of time under extreme temperatures?** EMPIRE® Silicone Rubber Coated Glass Cloth — Class H insulation — is suitable for a temperature range of —70° F to 400° F . . . will not crack or become brittle under these operating temperatures . . . offers good chemical resistance.



3. **Looking for a Class H molding plate?** Silicone molding plate which could not be produced successfully with mica splittings can now be manufactured from ISOMICA (continuous built-up mica sheets). ISOMICA silicone molding plate has excellent moldability . . . excellent retention of shape . . . high degree of homogeneity.



4. **Need reliable silicone-glass, silicone-asbestos and silicone-rubber-glass insulating materials?** Twice the amount of water ordinarily applied for bushing flash-over tests was sprayed on this Class H Core and Coil Assembly, which was under full voltage excitation. The MICO insulation was unharmed.

When *you* turn to Class H, take advantage of MICO's experience in this fast-moving field. MICO has the finest equipment in the country for producing extremely high quality silicone fabrics, silicone laminates and silicone-mica combinations.

MICO produces a complete line of Class H insulating materials in addition to all standard types . . . and fabricates special parts to specifications. We will be glad to consult with you about your electrical insulation problems. Write today.

*Trade-mark

MICA *Insulator* COMPANY

Schenectady 1, New York

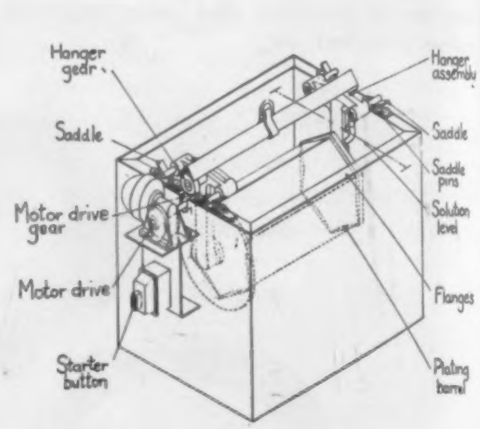
Offices in Principal Cities

LAMICOID ® (Laminated Plastic) • MICANITE ® (Built-up Mica) • EMPIRE ® (Varnished Fabrics and Paper) • FABRICATED MICA • ISOMICA*

For more information, turn to Reader Service Card, Circle No. 362

It consists of a closely coupled three phrase transformer, saturable core type three phase reactor in the primary circuit, control windings, and a selenium rectifier stack.

Remote control of welding operations is available, using either a foot or hand operated unit. Any number of the units can be paralleled for greater output, and panel-mounted voltmeter and ammeter can be supplied.



Barrel-Type Plating Tank Improved

Hanson-Van Winkle-Munning Co., Matawan, N. J., has marketed an improved Mercil-type tank for barrel electroplating which, according to the company, will handle any type of plating with the exception of chromium.

Improvements claimed for the unit are: turned in flanges, reducing space; more compact motor drive, with the drive shaft located above solution level precluding leakage through the tank wall; redesigned saddles to aid in positioning barrel; and improved hangar assembly to assure proper alignment of gears and cylinder.

Other features include a bottom drain, melamine bushings for insulating bronze hanger pins, flexible dangler contacts on the barrel, coil risers extending over the top of the tank, and two anode rods for each cylinder on single as well as multiple units.

Constructed of $\frac{1}{4}$-in. double electric welded steel plate, the tank comes in two sizes, one with a 224 and one with a 225 gal solution capacity. For acid solution, the tank is

New Materials, Parts and Finishes

lined with 3/16-in. vulcanized rubber or plasticized PVC. For cyanide solutions, the tank is provided with rough wire glass in back of the anodes.

Either melamine or Plexiglas cylinders may be used with the tank. With the former, solution temperatures up to 210 F may be utilized while with the latter, 180 F is maximum.

New Tool Cold-Welds Aluminum Sheet or Foil

A tool for the lap welding of aluminum sheet or foil without heat, electricity, flux or chemical of any kind has been developed by the *Utica Drop Forge & Tool Corp.*, 2409 Whitesboro St., Utica, N. Y.

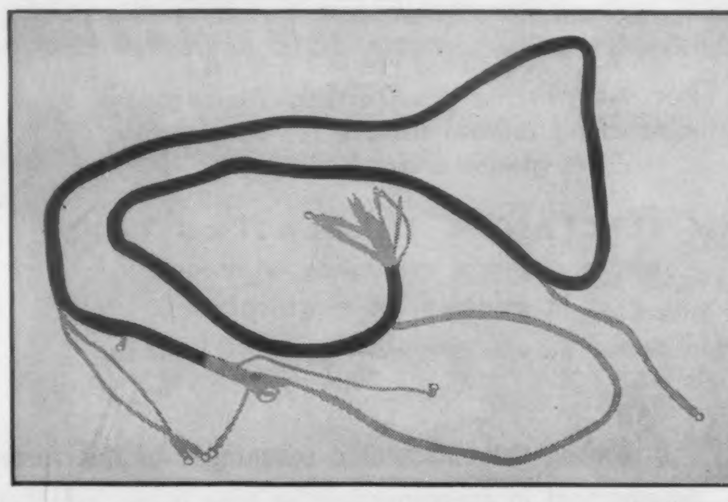
The Koldweld tool #KL-10 is hand operated and accomplishes the welding of aluminum foil, sheet, shaped extrusions or strip by pressing the surfaces of the parts together between special dies. To prepare the metal surfaces it is necessary to clean them with a steel wire scratch brush (or similar mechanical action) to remove surface oxidation, dirt and grease.

The manufacturer says that the tool will join aluminum and electrical copper in thicknesses of 0.001 to 0.040 in. or an over-all maximum thickness of 0.080 in. Dissimilar sizes and metals may be welded with the device, though for each total thickness of material, a different sized interchangeable die is required. According to the company, the KL-10 will handle all types of aluminum (except 56S and aircraft qualities in the T temper) and electrical copper.

Weld accomplished by the tool are said to meet the same tests as

Polyken tape holds down the cost of special harnesses

Harness wraps of *Polyken* Tape can be quickly formed with an automatic taping machine or by hand in any diameter or length whenever they're needed.



Polyken Tape holds *and protects* wiring assemblies. Polyethylene backing is non-corrosive, solvent resistant and has high dielectric strength.

CLARK EQUIPMENT COMPANY PRODUCES THEIR OWN SPECIAL HARNESSES . . . WITHOUT DELAY AND AT BIG SAVINGS!

Any variation from the standard wiring harness meant added expense and delay for the Clark Equipment Company of Battle Creek, Michigan. New blue prints had to be drawn, new specifications had to be detailed, and special orders had to be placed.

To speed up the work and cut the cost, the Clark Equipment Company now produces all special harnesses right at their own plant. With an automatic taping machine and *Polyken* Tape, they turn out tailor-made harnesses quickly and easily. They use *Polyken* Tape No. 822 in ¾″ width. This is a highly versatile industrial adhesive tape that can be used to assemble harnesses in any diameter or any length by machine or by hand. This tape has a polyethylene backing that protects the wiring assembly from moisture, battery acids and hydraulic oils.

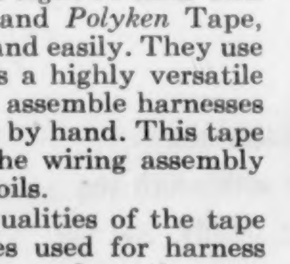
Although you may not require the same qualities of the tape used by Clark, there are many other tapes used for harness wrapping in the *Polyken* line. Eliminate delay and cut the costs of your harness wraps this same tested way.

TAILORED TO YOUR JOB

Polyken®

INDUSTRIAL TAPES

POLYKEN PRODUCTS DEPARTMENT OF THE KENDALL COMPANY



Polyken, Dept. MM-B
222 West Adams St., Chicago 6, Illinois

For physical properties and further information on *Polyken* Tapes for harness wrapping, please send me your FREE BOOKLET, *Tape is a Tool.*

Name________ Title________

Company________

Street Address________

City________ Zone____ State________

• **For more information, turn to Reader Service Card, Circle No. 476**

New Materials, Parts and Finishes

applied to conventional welds. When the weld is pulled apart fracture occurs around the periphery of the spot, pulling a slug from one of the sheets.

Manganese-Nickel Welding Electrode

The *Sulz-Sickles Co.*, 134 Lafayette St., Newark, N. J., has marketed 11 to 13½% manganese-nickel welding electrodes which are said to run as easily as stainless or mild steel electrodes.

The Flo-Kote rods, according to the company, can be used in any position and will join dissimilar metals. No peening is necessary, and the deposit can be cut with an ordinary oxy-acetylene flame.

New Instrument Aids Surface Measurement

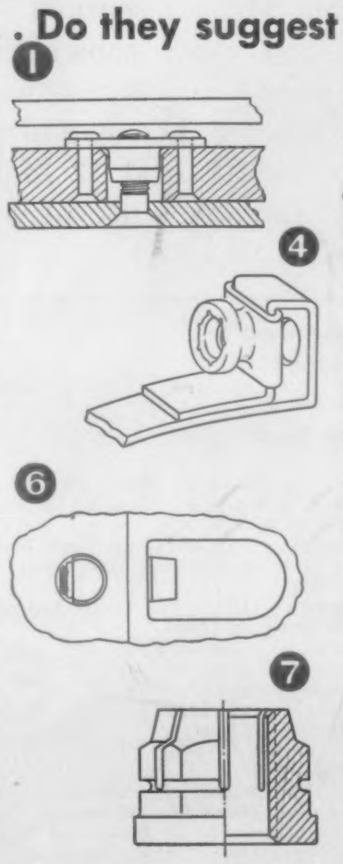
An instrument for measuring the roughness of any surface in a range of 1 to 1000 micro-inches average deviation from the mean surface is being manufactured by the *Brush Electronics Co.*, 3405 Perkins Ave., Cleveland, under license from the General Motors Corp.

A variable cut-off switch on the Surfindicator permits the separation of waviness and roughness characteristics of surfaces by filtering out wave lengths exceeding 0.003, 0.010, or 0.030 in., a feature of importance in applications such as bearing surfaces and highly stressed parts.

When the diamond tip stylus moves across the peaks and valleys

Can you use these new self-locking Nuts?

Designed for special applications . . . Do they suggest solutions to *your* design problems?



1 **TWO-LUG INVERTED ANCHOR NUT** For use where clearance or other considerations make it necessary to mount the nut upside down. Clearance hole must be provided for the barrel. Nylon inserts.

2 **LIGHT HEX NUT, KEL-F INSERT** Special KEL-F insert provides the self-locking, vibration-proof features of all ELASTIC STOP® nuts, for operation under extremely corrosive conditions—or exposed to strong acids—such as fuming nitric.

3 **TWO-LUG HIGH-TENSILE ANCHOR NUT** For use with 160,000 psi bolts, in blind mounting or in applications where ease of maintenance makes an attached nut desirable. Nylon inserts.

4 **SELF-LOCKING CLAMP NUT** For installation around the clamp leg, or on slotted strips where a random lengthwise positioning of the nut is necessary. Red nylon locking insert.

5 **HIGH-TEMPERATURE, CLOSE CLEARANCE DOUBLE-HEX NUT** For applications where weight, wrenching area and elevated temperatures are all major considerations. Temperatures to 1200° F.

6 **LIGHTWEIGHT BARREL NUT** Barrel nuts permit the use of lighter forgings—and simplify machining. "Bathtub" type recesses are necessary for the bolt head only, since the barrel nut fits into regular drilled hole. Wrenching is simplified because the nut cannot turn. This is a lightweight version of the ESNA high-tensile barrel nut, for 160,000 psi bolts. Nylon inserts.

7 **ACCESSORY MOUNTING NUT** High-temperature nut for mounting generators or similar accessories having a keyhole-type mounting flange. Large base diameter compensates for seating area lost to slot in flange. Nut straddles slot without Brinnelling the flange. Temperature to 550° F.

8 **HIGH-TEMPERATURE FLOATING-BASKET ANCHOR NUT** Specially designed for applications where a lesser degree of accuracy in alignment of nut and bolt hole is desirable. To 1200° F.

Mail coupon for design information

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. N48-261, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send details on the following fasteners:

☐ 1 ☐ 3 ☐ 5 ☐ 7 ☐ Here is a drawing of our product. What self-locking fastener do you suggest?
☐ 2 ☐ 4 ☐ 6 ☐ 8

Name______________________ Title______________

Firm______________________________________

Street_____________________________________

City_____________________ Zone_______ State__________

For more information, turn to Reader Service Card, Circle No. 408

of the surface to be measured, the microscopic mechanical motion is transformed by a movable plate vacuum tube transducer into electrical signals. These signals are amplified and indicated on the meter as surface roughness in micro-inches. The operator selects the proper roughness and cut-off scales, guides the pick-up over the work, and reads the meter.

The Surfindicator is equipped with Precision Reference Specimens which comply with the ASA Standard B 46.2, and the SAE requirements, thus ensuring standard calibrations. The unit weighs 15 lb and can be set up in any location where 115 v, 60 cycle current is available.

Drawer-Type Oven Heats Phenolic Laminates

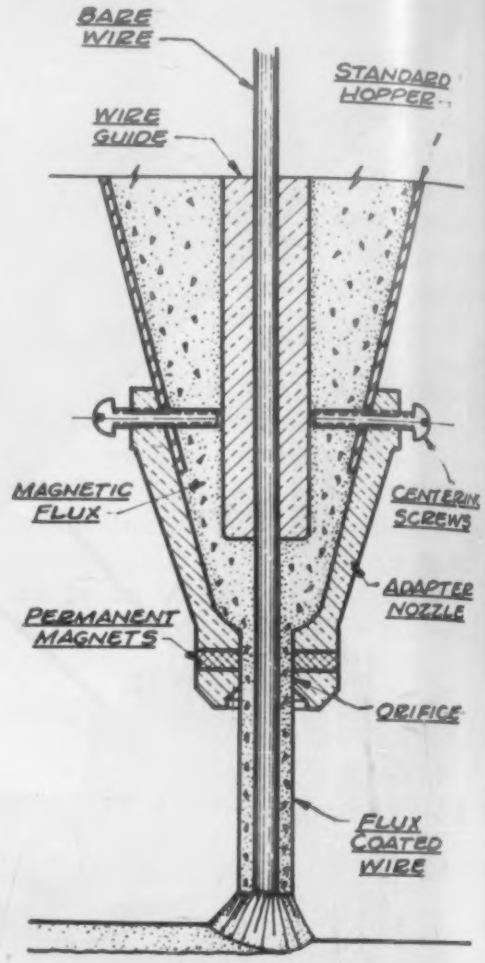
A drawer-type oven equipped with push button controls to close the drawer and reset the timer for subsequent cycles has been developed for preheating laminated phenolic materials prior to forming. The forced convection oven is said to insure the complete surrounding of the material with uniform high temperature air, according to the manufacturers, the *Coats Electric Mfg. Co.*, 3419 11th Av. S.W., Seattle 4, Wash.

The maximum temperature is 600 F and the timer is set to limit the soak period and automatically open the drawer when this period is finished. The unit requires 15 kw input, and interior baffles are said to allow temperature control within ± 5 F with proper instrumentation. Drawer size is 54 x 48 x 6 in. deep.

(Continued on page 162)

For more information, Circle No. 456

New Materials, Parts and Finishes



Squirt Welder Adapted for Magnetic Flux

A simple nozzle adapter has been developed by the *Stoody Co.*, Whittier, Calif., which allows the use of the conventional semi-automatic or "squirt" welder with magnetic flux. The resulting process is a combination of the squirt welding technique, which uses a granular non-magnetic flux to produce the common submerged melt deposit, and the magnetic flux method of automatic welding perfected by Brown Boveri in Switzerland.

This latter process employs the magnetic field surrounding the bare electrode to coat the rod with the granular magnetic metallic flux immediately ahead of the welding arc.

In the Stoody adaptation, the magnetic flux is fed from the standard hopper by gravity to a cup around the contact jaws. When the arc is established, the magnetic lines of force cause the flux to adhere to the wire, producing a coated electrode. The amount of flux applied is governed by the size of the orifice in the cup. Permanent magnets in the cup act as a dam for the flux when the arc is broken.

(Continued on page 164)


20% STEEL SAVINGS

New Materials, Parts and Finishes

This adaptation of the Brown Boveri method to the squirt welder is said to offer several advantages. In build-up and hard-facing, this process is said to provide deposition rates of 8 to 20 lb of metal per hr with the 5/64 or 3/32 wires, depending on the amperage. According to the company, the deposits are sound, with the consistency and uniformity characteristic of the automatic welding method. Another advantage lies in the fact that the process employs an open arc, allowing the operator to see the weld at all times.

The company plans to manufacture a series of alloys designated Stoody Magnecote for use with the process. The first material of this line released is Stoody Magnecote 301 which is said to produce a manganese deposit of full Hadfield properties.

Stiffness Tester Offers Increased Range

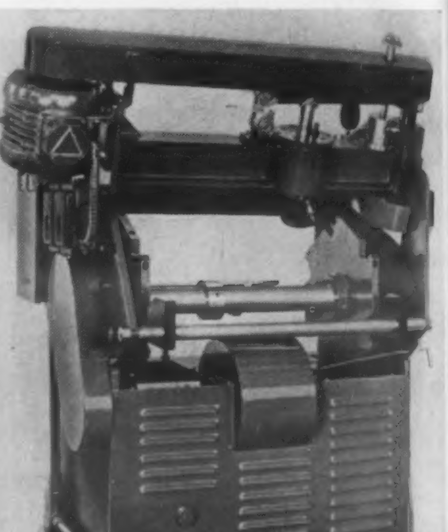
The Taber Model 150 Stiffness Tester, designed for determining both initial and basic stiffness of sheet and wire specimens, now has eight instead of six test ranges, in-

New Materials, Parts and Finishes

creasing the sensitivity of the instrument.

Developed by the *Taber Instrument Corp.*, 111 Goundry St., N. Tonawanda, N. Y., the device also measures flexural rigidity of very thin materials such as cellophane, metal foil, synthetic fibres, watch springs and brush bristles with the SR150-14 attachment which magnifies dial readings 100 times. Test length, angle of deflection and rate of loading are all standardized, simplifying coordination of test results from different laboratories.

Readings are taken directly from the dial and a triple-cut shear blanks out precision specimens thereby standardizing the size of the test specimen.



Semi-Automatic Hardness Testing Machine

A new semi-automatic Brinell testing machine has been marketed by the *Detroit Testing Machine Co.*, 9390 Grinnell Ave., Detroit 13.

According to the company, the machine reduces the manpower required for testing operations by half as it automatically indexes test pieces through both spot grinding and Brinell testing stations at the rate of 400 pieces per hour.

Designated model RCB, it has a 30-in. work opening and is hydraulically operated. It is now being used to test crankshafts.

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- ***Russians Confer on Powder Metallurgy***
- ***Causes of Brittle Fracture in Steel***
- ***Properties and Specs for Cellular Rubber***
- ***How Boron Affects Overheating of Steel***
- ***Silver Bearing Alloy Tested***

Soviet Progress in Powder Metallurgy Discussed

With the rapid development of powder metallurgy, interest in the process has been international in scope. A condensed report on a conference of Russian metallurgists early in 1953 appeared in the July, 1953 issue (Vol. 33) of *Vestnik Mashinostro.*

Since conservation and efficient utilization of materials is of vital interest behind the Iron Curtain, as elsewhere, many of the papers read at the conference dealt with possible use of metal waste and low grade material, e.g. pyritic slag, in the production of iron powders.

(It is interesting to note that, as well as in baseball, the Russians claim another "first" in the preparation by P. G. Sobolevskii in 1827 of platinum articles by powder metallurgy methods. No mention was made at the conference of Wollaston's work with platinum powder in England in the 1820's.)

As opposed to the theoretical, one of the more practical papers was presented by N. N. Timoshenko regarding iron powders such as those made in one State metallurgical factory. For purposes of Soviet standardization the following five grades were proposed, though a subsequent decision was not reached:

	Fe	C	Si	Mn
A.	98.5%	0.05%	0.05%	0.05%
B.	98.0	0.05	0.25	0.5
C.	96.0	0.15	0.45	0.5
D.	94.0	0.25	1.0	0.5
E.	91.0	0.25	Adjusted	Adjusted

Among the methods described for the production of iron powder was that evolved by the Academy of Science using pyritic slag reduced in a natural gas. The product was said to differ little from that of the Eddy method, to be cheap and to have high strength and plasticity. The use of iron or steel waste with or without pyritic slag was also said to be a cheap process, including preliminary hydrolysis of chlorides, followed by reduction of iron oxides with hydrogen.

Both ferrous and other powders such as phosphor bronze, as well as pure metals were obtained by atomizing melts in a gaseous atmosphere and centrifuging. Under mass production methods, output from one unit was said to be up to 5 tons per hr, at low cost.

Several papers pointed up the close attention being paid in Russia to the development of metallo-ceramic bearings of controlled porosity. Coefficients of friction were less and loads greater in the iron-graphite bearings than with conventional bearings, such as babbit or bronze. With a porosity of 25%, loads ranged from 70 kg per cm² at 0.5 m per sec, to 5 kg per cm² at 4 m per sec. In the coal mines with loads of 20 kg per cm² and a running speed of 1 m per sec, porous iron powder bushings proved more durable, cheaper, and required less attention than conventional ball bearings.

Results of testing in the Russian automotive industry were also said to prove the superiority of bi- and tri-metallic (ceramic) bushings and bearings over the conventional kind.

An improved method of electrical pressing was described by M. T. Vasil'ev which, among other things, permitted better controlled porosity in anti-friction materials such as ferro-aluminum alloys and porous cast iron. Pressing and sintering are simultaneously achieved without special reducing atmospheres and with lower pressures than for ordinary cold pressing.

Some Unusual Aluminum Extrusions

These interesting shapes, which appeared in the Nov., 1953 Revue de L'Aluminum, are examples of some aluminum alloy extrusions produced in France. The alloys used are 1% magnesium; 0.5% manganese, 3.5% magnesium; 0.5% manganese, 5% magnesium; and <0.8% manganese, 1% magnesium, and 1.2% silicon.

(Continued on page 170)

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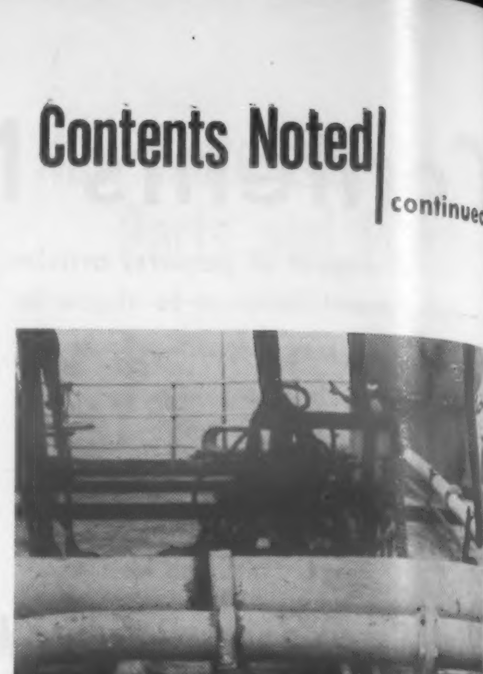

Typical brittle fracture in the deck of a ship.

Conferees in Scotland Discuss Brittle Fracture of Steel

The basic problem of brittle fracture is to discover why certain steels are able to support a normal or cleavage stress until the shear stress overcomes the shear resistance and plastic flow occurs, while others will fracture by simple cleavage before any appreciable plastic deformation sets in.

At a conference held by the *West of Scotland Iron and Steel Institute* in Glasgow in May, 1953, papers from Sweden, Belgium, Britain and the U.S. were presented which contributed much in the way of clearer and more exact knowledge of brittle fracture in steel. Three of the papers deal broadly with the mechanism of brittle fracture, one with problems in testing, three with practical aspects of the problem, while the eighth presents a review of brittle fracture studies in this country.

Fracture Mechanism

The paper by P. Matton-Sjoberg (The Mechanism of Fracture in Impact Tests) points out that the cracking process starts always in the ferrite. The author further states that

Contents Noted continued

it is a highly localized phenomenon occurring within the elastic range, the volume of the material involved in the process being extremely small. The only condition necessary for brittle fracture is that the stress system must be of such intensity that normal stresses greater than the critical streses are obtained on the cleavage planes of the ferrite. This condition is aided by every factor obstructing the plastic deformation of the ferrite by slip, such as lowering the temperature, increasing the loading rate, aging processes, and unfavorable arrangements of the structure.

T. S. Robertson and D. le M. Hunt in their paper (The Propagation of Brittle Fracture) state that results of their tests show that the transverse force for propagation of a crack at a given temperature and for a given material is constant whatever the length of the crack, while the force for propagation varies only slightly with temperature. This value of transverse stress is apparently required at all times to maintain crack propagation and is not affected by the length of the existing crack nor by the length of the sound material ahead of the advancing crack.

Improving Notch Ductility

I. M. MacKenzie (Notch Ductility of Mild Steel Ship Quality Plates) explained the results of tests conducted on plates varying in thickness from 1/4 to 1 1/4 in. The results of the first tests which attempted to determine the causes of variation in notch ductility of plates of the same thickness, revealed the significant factors to be the finishing temperature and the manganese, phosphorus and nitrogen contents. Subsequent tests conducted on plates of varying thicknesses showed the significant factors to be finishing temperature, plate thickness, and phosphorus content. The author points out, however, that there are unexplained differences in notch ductility values which might be associated with differences in austenitic crystal growth and transformation characteristics.

MacKenzie suggested that the three most promising methods of improving notch ductility are by increasing the manganese content, normalizing after rolling, and deoxidizing with silicon and/or aluminum.

(Continued on page 172)

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U. S. Studies

S. L. Hoyt (Brittle Fracture Studies in the United States) concludes that the initiation of brittle fracture depends on the cohesive strength and the shear strength, while the propagation depends on the cohesive strength and the energy of separation. He also introduces the concept of the "match point" which is that point at which the ratio of the normal stress to the maximum shear stress equals or matches the ratio of the cohesive strength to the shear strength. This point gives the conditions of test bar geometry and material properties at which the stresses match the strength properties.

The author points out two approches to overcoming the risk of such failures. Rather than substituting a steel with a higher value of notch toughness, the proper remedy might be a modification of design to produce a better streamline flow of stress. Or, on the other hand, larger safety factors might be incorporated such as rivetting along the longitudinal seams of a ship or the incorporation of special high notch ductility plates as safety zones at dangerous stress points in a structure.

Weld Metal As a Source of Brittle Fracture in Steel Structures

There has been a trend, through the war years and afterwards, toward a greater utilization of welding as opposed to riveting in the fabrication of heavy steel structures. Since these welded butts or seams will not isolate a fracture to the plate where it originated, but will allow it to progress into others, one such fracture can be disastrous.

W. G. Warren, R.C.N.C., and H. G. Vaughan, in a paper published in the Oct., 1953, *Transactions of the Institute of Welding* (British), discuss this problem from the standpoint of the weld metal itself as the source of failure.

The authors point out the importance of micro-fissures lying predominantly in planes transverse to the line of weld. A longitudinal crack once started may then progress

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by linking these fissures together, forming a fracture.

In attempting to determine the cause of the fissuring of the weld metal, it was found that three main factors in the electrodes appeared to influence the tendency to fissure: 1) The fluidity of the slag which, when high, allows the slag to flow out of the weld more easily, producing a cleaner deposit; 2) the basicity, which affects the degree of desulferization; and 3) the hydrogen potential. The lower this potential, the less hydrogen there will be available to diffuse into small voids, creating aerostatic pressures which aid in the initiation of cracks.

The authors further point out that the fissuring is also affected by the cooling rate, the hardness of the weld metal, and the type of microstructure.

The employment of electrodes producing weld metal free from fissures should be expected to materially reduce the incidence of brittle fracture of weldments. Of the electrodes tested, those that were lime coated and having a basic fluid slag, and low hydrogen potential, produced welds with practically no fissuring. The use of this type of electrode plus a moderate pretreatment should gain this objective, though the authors suggest that further research into this aspect of electrode design is advisable.

Effect of Boron on the Overheating Properties of Steel

In an article in the August, 1953 issue of *Metal Progress*, J. Field describes investigations prompted by the discovery that an SAE 1045 steel to which 0.003% boron had been added to increase hardenability showed evidence of overheating at forging temperatures previously found satisfactory for this grade of steel without boron.

The material studied was representative of seven commercial basic open-hearth heats of 1045 steel. After the addition of the alloys, the specimens were tested for impact, tensile strength and end-quench hardenability.

It was found that the addition of

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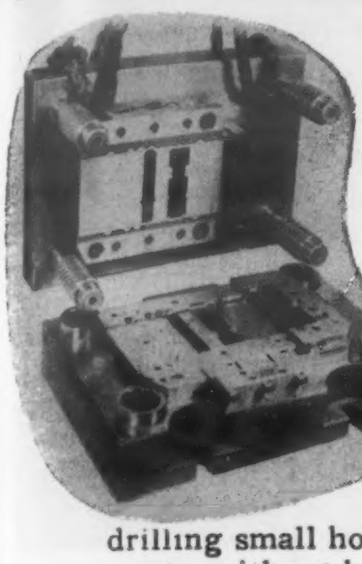

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0.003% boron in the form of the 12% boron alloy lowers the temperature at which overheating normally occurs, while the addition of boron in the form of the special alloy addition agent (Al, 13; Ti 20; Zr, 4; Mn, 8; B, 0.50; Si, 5%) does not affect the normal overheating properties of this steel. The addition of 0.003% boron by combined additions of the special alloy and 12% boron alloy results in the occurrence of facets at low temperatures, but to a lesser degree than are obtained with only the boron alloy addition alone.

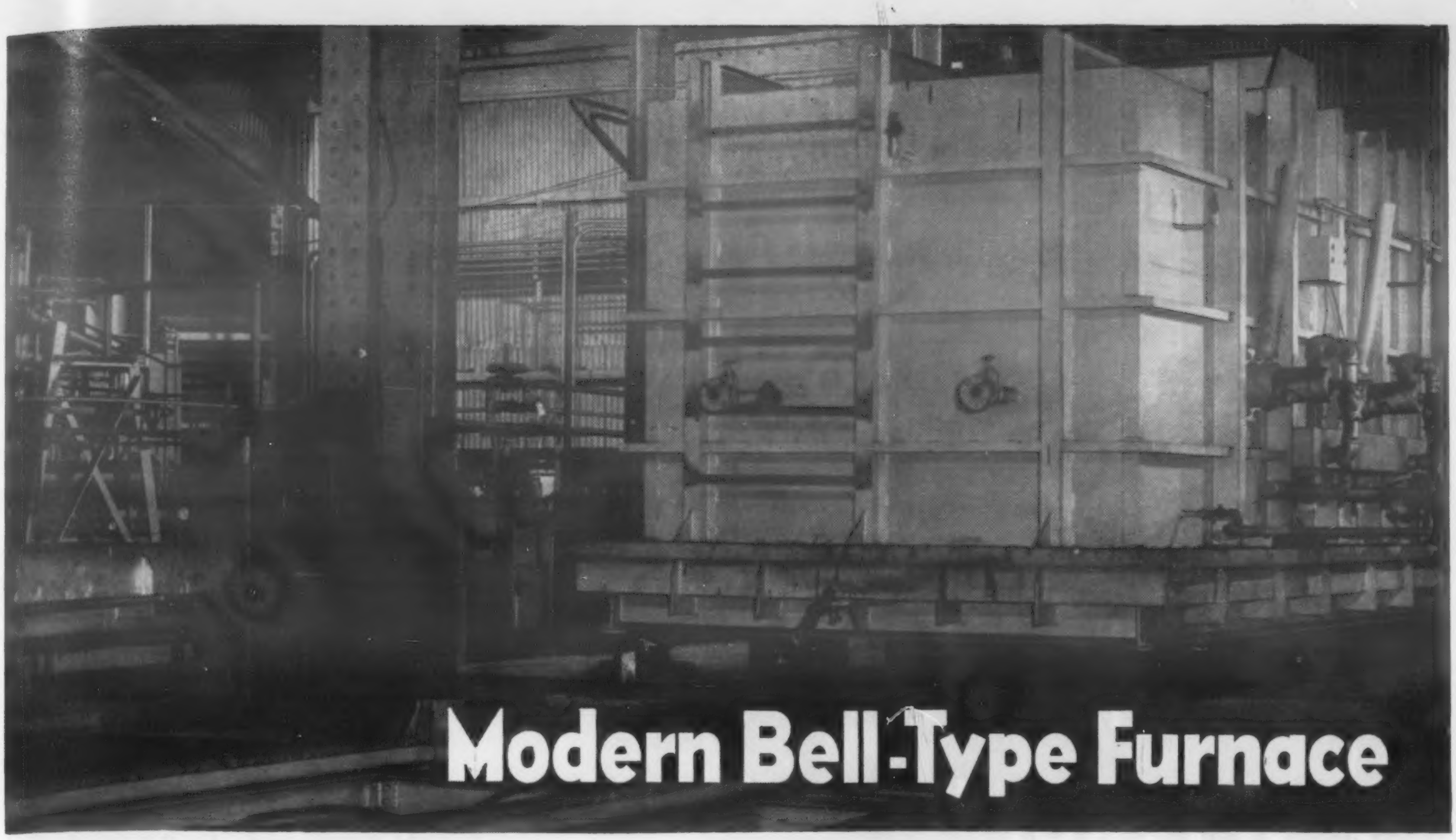
In questioning why the addition of the special alloy does not lower the overheating temperature, three alternatives are postulated. It is due either to the presence of zirconium and titanium, the low amount of boron, or the combined effect of the two factors.

The tests also showed that the occurrence of overheating lowers the ductility of the steel as measured by impact tests and by values for elongation and reduction of area in tensile tests.

However, the author points out that due to the limited scope of the investigations, the conclusions reached apply solely to the two boron ferro-alloys commonly used in the production of boron steels and should not be applied to other boron ferro-alloys or to modified practices in which the 12% boron alloy might be added in less than the recommended amounts or in combination with other elements.

Copper-Silver-Lead Bearing Alloy Tested

The rapid development of the internal combustion engine has greatly increased the severity of conditions under which the bearing alloys must operate. Though the tin-base alloys remain the most widely used for this purpose, they do not retain compressive and fatigue strength at the high operating temperatures of today's engines, and though the cadmium-nickel and cadmium-silver alloys have better fatigue properties at these tem-



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peratures, they are susceptible to corrosion by oil acids.

In an article in the Nov. 1953 *Metallurgia* (British), G. Llewelyn, B.Sc., AIM, discusses the results of tests conducted at the Bristol Aeroplane Co. in developing a copper-silver-lead bearing alloy which would provide the desired properties when cast on a steel shell. These tests have shown that a 30 copper, 30 silver, and 40% lead alloy can be readily bonded to mild steel using standard casting techniques and that it does fulfill the major requirements of a bearing alloy.

The mechanical properties at elevated temperatures are better than those of the tin-base alloy, while the compressive strength at these temperatures is equal to that of the 30% lead, copper-lead alloy, and much better than the tin-base alloy. Theoretically then, the alloy should be quite suitable for use with high loads at bearing temperatures and should not suffer from fatigue failure. Since a thin lead film is formed on the surface during running, the coefficient of friction is low, eliminating the need for perliminary lead plating of the bearing.

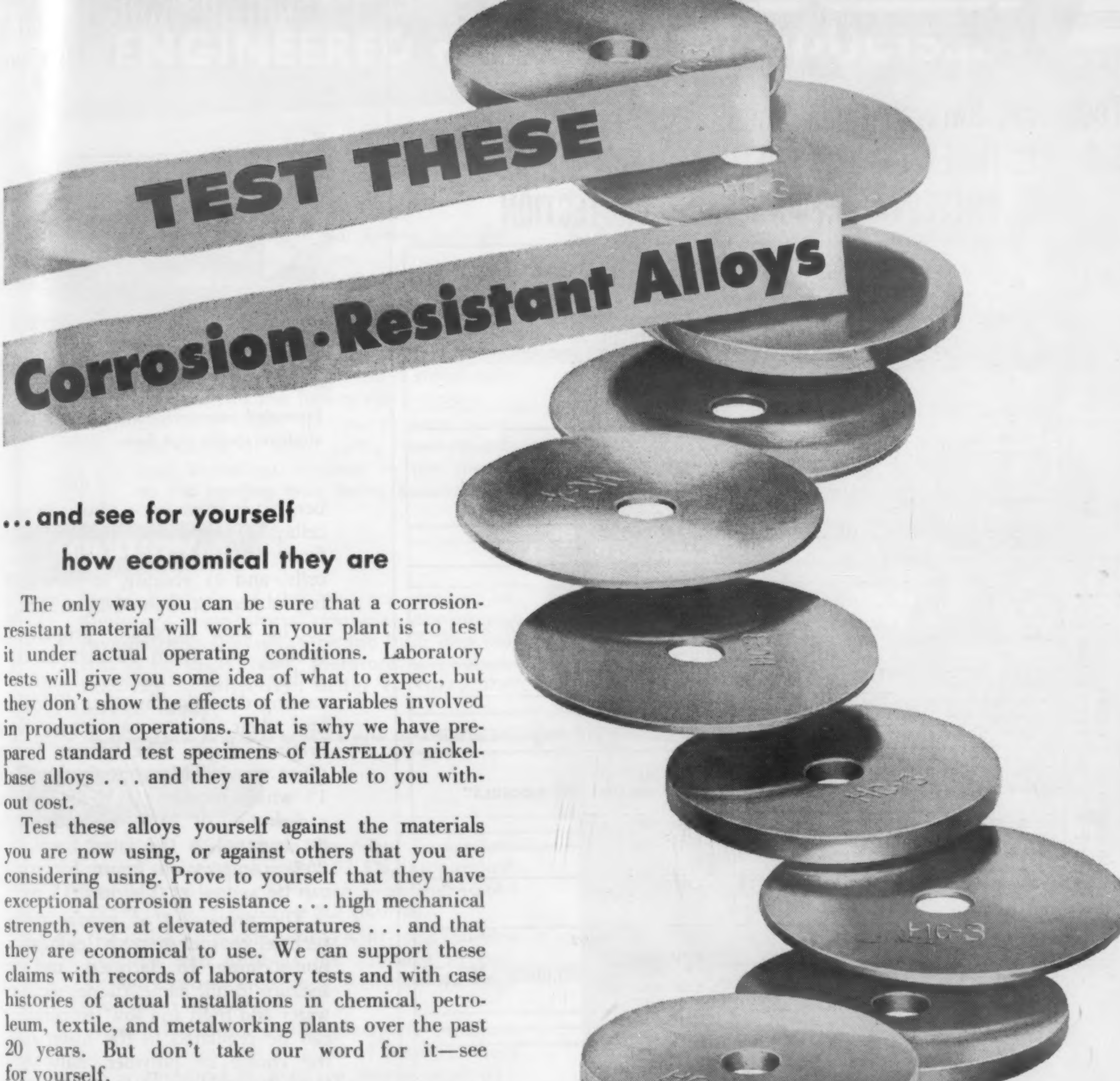
The resistance to corrosion although not so high as that of the tin-base alloy is good enough to ensure trouble-free operation with an efficient oil filtering system. The coefficient of expansion is not unduly high.

The author finally points out that though laboratory tests have shown that this alloy does possess most of the desirable properties associated with bearing alloys, only actual service tests can fully assess its qualities.

Engineering Properties and Specifications of Cellular Rubber

In a paper presented at the annual meeting of *The American Society of Mechanical Engineers*, Dec., 1953, G. R. Sprague and A. F. Sereque pointed out the properties and characteristics of four types of cellular rubber and expanded polyvinylchloride.

The four types are: 1) sponge rubber, which has open cells and is made of dry rubber; 2) foam rub-



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The only way you can be sure that a corrosion-resistant material will work in your plant is to test it under actual operating conditions. Laboratory tests will give you some idea of what to expect, but they don't show the effects of the variables involved in production operations. That is why we have prepared standard test specimens of HASTELLOY nickel-base alloys . . . and they are available to you without cost.

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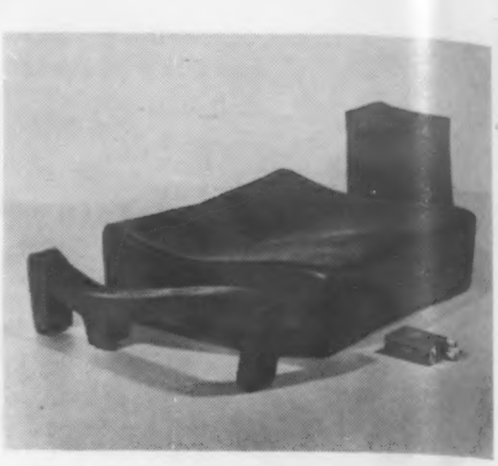

Expanded polyvinylchloride is used in this airplane ejector seat base.

ber, made from latex, also with open cells; 3) expanded rubber, made from dry rubber and having closed cells; and 4) ebonite, or hard cellular rubber not defined by ASTM.

The most important property of sponge and foam rubbers is their ability to be compressed without causing distortion in other directions, and their ability to recover their original shape. The firmest sponge given an ASTM rating is the Class 15 which requires 17 to 24 psi for a deflection of 25%, while the softest material is the latex foam, the 25% compression figure for which can be as low as 0.10 to 0.15 psi.

The properties of sponge rubber such as tensile strength, elongation, non-staining to lacquer, and resistance to oil, flame, ozone, weather, water and high and low temperatures can be regulated in the material by the choice of polymer, natural or synthetic rubber, and special compounding. Since rubber is naturally resistant to fungus and vermin, under most conditions no additional protective ingredients are necessary.

In general, high temperatures harden synthetic and soften natural rubbers. A temperature of 175 F is the limit for continuous use of standard natural compounds, while 225 F continuous, and 300 F intermittent are the highest for specially compounded stocks. For higher temperatures than these, the synthetics must be used, the best to date being silicones which are as soft at —90 F as at room temperature and harden only slightly after 24 hr at 550 F.

Expanded rubber, though similar to sponge rubber in appearance and feel, has non-interconnecting, nitrogen-filled cells which make it permanently water-proof. It will

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   - (b) The long, deep, narrow pockets were the cause of sand being washed off and becoming trapped in the metal as the casting was being poured.

SOLUTION:

Stress analysis of the original design, in Superior's own stress analysis laboratory, revealed the stresses to be too high and the ribs to be stress risers. Therefore, the design must be modified in order to carry the service loads.

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1. Superior's Engineered Foundry Design reduced the critical stress 57.5%, eliminating service failures. Strength was increased 235%, weight reduced 3.2 pounds.
2. The redesign is compatible with good foundry practice and enables the foundry to consistently produce castings that meet the high standards required.
   - (a) Elimination of the heavy rib junctions reduces the number of feeding risers required to produce sound castings.
   - (b) Trapping of sand in the metal during pouring is prevented because the deep pockets have been reduced.

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have the same compression value as a sponge rubber twice its density, making it desirable for applications where weight is an important factor.

Cellular ebonite is a rigid, firm, extremely light material with a very high structural strength-to-weight ratio. It can be made resistant to oils, acids, and temperatures to 290 F. It is primarily used for carburetor floats in aircraft and tanks.

Expanded polyvinylchloride is a relatively new material quite similar to expanded rubber, but with the special property characteristics of the base material. It is extremely light weight, usually with closed cells, and can be made in densities of 3 lb per cu ft and upwards.

ASTM System for Specifying Cellular Rubber Compounds

Oil Resistance:
(Designated by Prefix Letters)

Designation	
R	For application where specific resistance to petroleum oils is *not* required. May be a compound of natural, synthetic or reclaim rubber or combination thereof.
SB	For applications requiring *low* (1) volume swell in petroleum oils. Must be a compound of synthetic rubber(s).
SC	For applications requiring *medium* (1) volume swell in petroleum oils. Must be a compound of synthetic rubber(s).

Cell Structures and Firmness:
(Designated by Middle Numerals)

	Designation	Compression Lb to Compress 1 Sq In. 25% (2)
Open Cell Sponge Rubber	10	1 ±1 —½
	11	3½ ± 1½
	12	7 ± 2
	13	11 ± 2
	14	15 ± 2
	15	20½ ± 3½

	Designation	Indentation Lb to Compress 50 Sq In. 25% (3)
Latex Foam (Cored)	21	9½ ± 3½
	22	17½ ± 4½
	23	28½ ± 6
	24	42½ ± 7½
	25	58½ ± 8½
	26	76½ ± 9½
	27	96½ ± 10½
	28	118½ ± 11½
Latex Foam (Uncored)	31	7½ ± 2½
	32	17½ ± 7½
	33	32½ ± 7½
	34	50 ± 10
	35	72½ ± 12½

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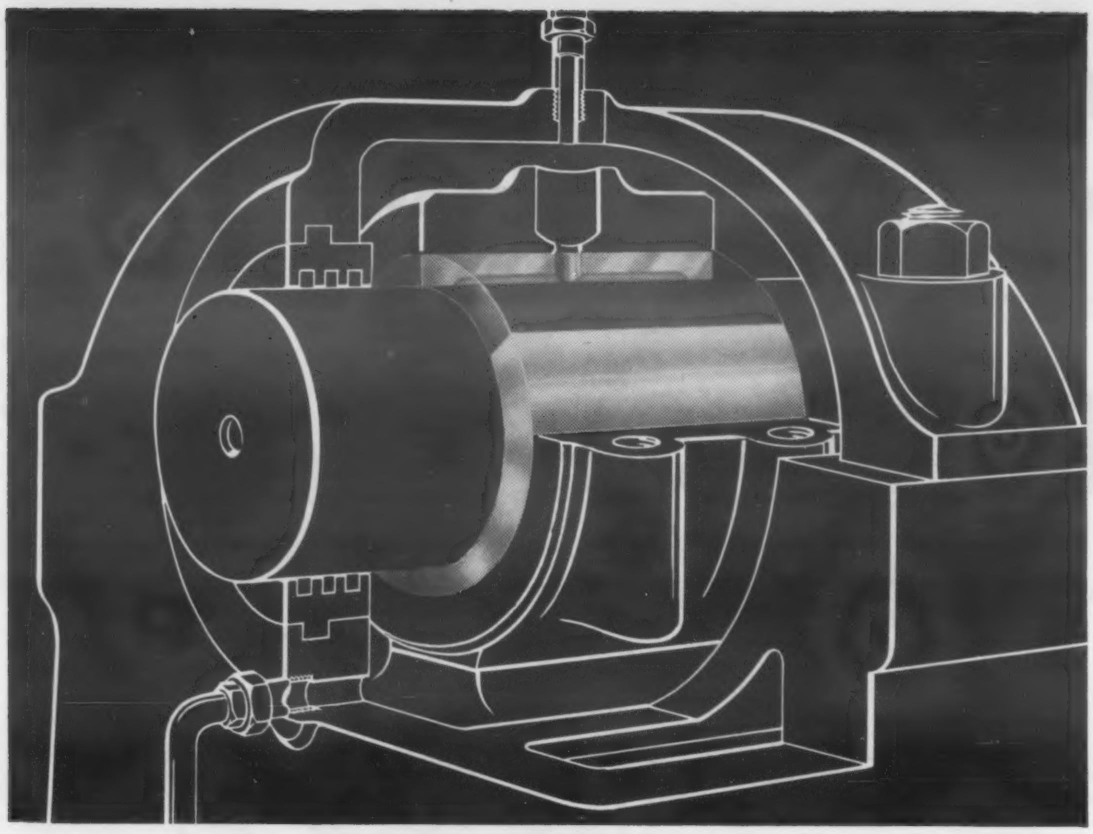

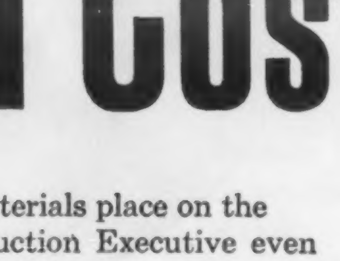

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continued

Special Requirements:
(Designated by Suffix Letters)

Designation	Test Required	ASTM Test Procedure
A	Oven aging	D573
B	Compression set	D395
C	Weather resistance	(4)
D	Special load deflection	D1056
E	Oil aging	D471
F	Low temp (—40)	(4)
FF	Low temp (—70)	(4)
G	Tear resistance	D624
H	Flexing	(4)
J	Abrasion	(4)
K	Adhesion	D429
L	Water absorption	(4)
M	Flame resistance	(4)
N	Impact	(4)
P	Staining	D925
R	Resilience	D945
Z	Performance or special test	(4)

Notes:
(1) As measured by ASTM D-471.
(2) See ASTM D1056-52T.
(3) See ASTM D1055-52T.
(4) Test to be arranged between manufacturer and purchaser.

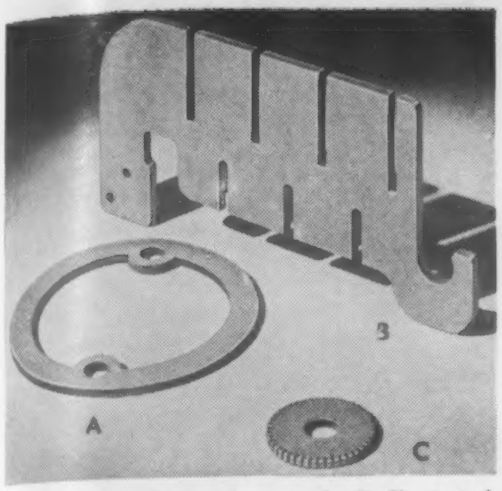
(Continued on page 186)

Watch For 1954 Materials Show

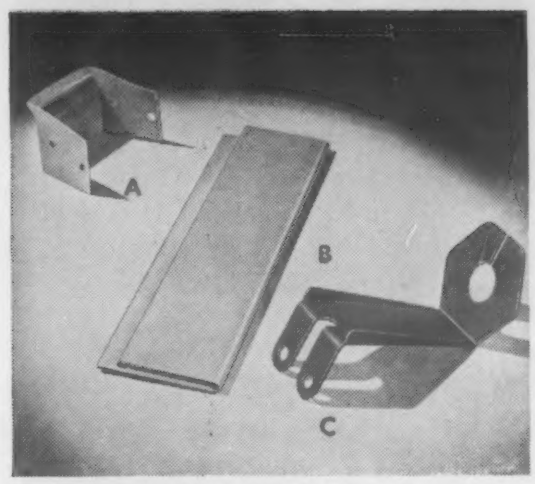
The second Basic Materials Show, the product development show which had its premiere in New York last June, will be held in the International Amphitheatre, Chicago, May 17-20.

Attendance at the first show exceeded advance estimates by a large number and as a result the exhibition space at the second exposition will be more than doubled and the number of exhibitors will be increased by about 50%.

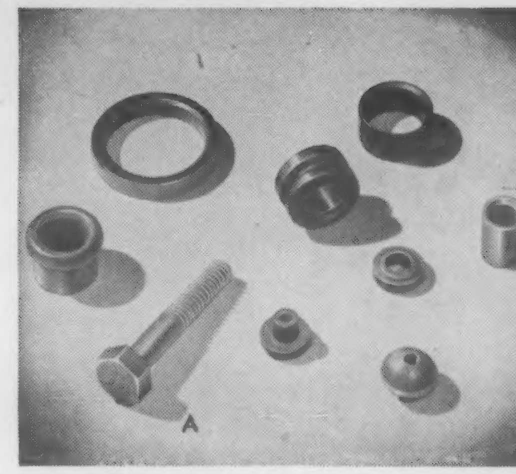
Exhibits are limited to companies producing basic materials which go into the manufacture of other products.



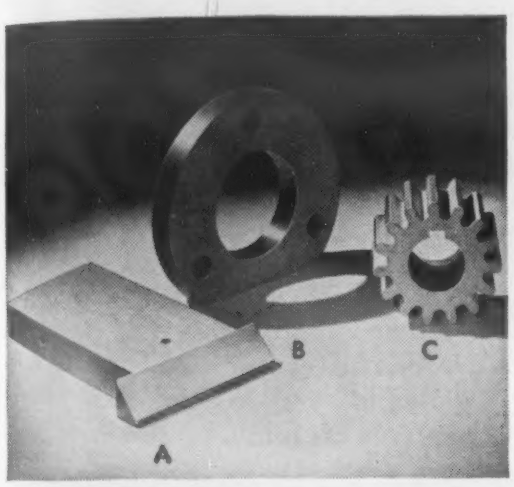
A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.



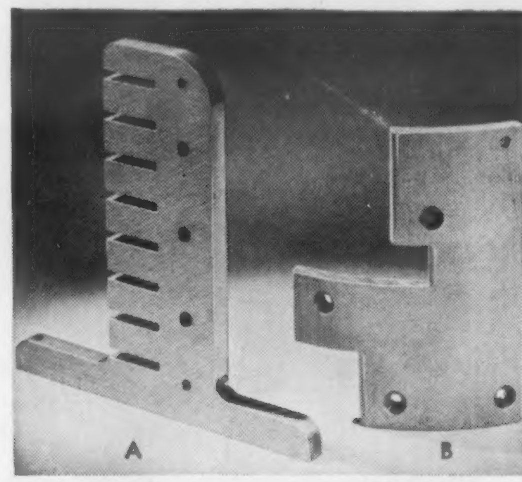
A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.



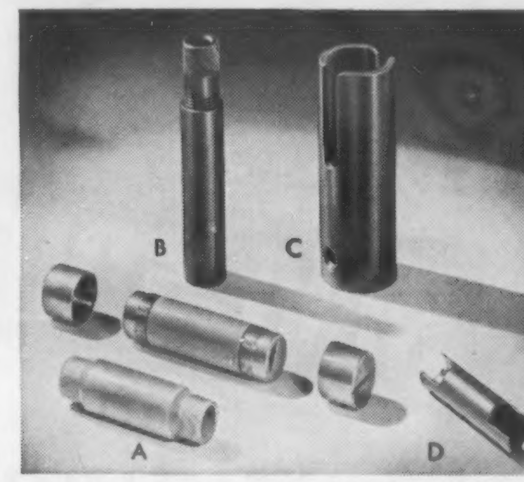
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, band saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, band saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw nothches. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

C-D-F fabricates and forms DIAMOND VULCANIZED FIBRE

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Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

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Contents Noted

Books

MODERN ELECTROPLATING. *Edited by Allen G. Gray. John Wiley & Sons, Inc., New York 16, N. Y., 1953. Cloth 6 by 9 in. 563 pp. Price $8.50.*

This book is a revision of the Electrochemical Society's earlier *Modern Electroplating.* Written by 39 experts currently active in the field, it covers modern electroplating practice and the basic theories currently held.

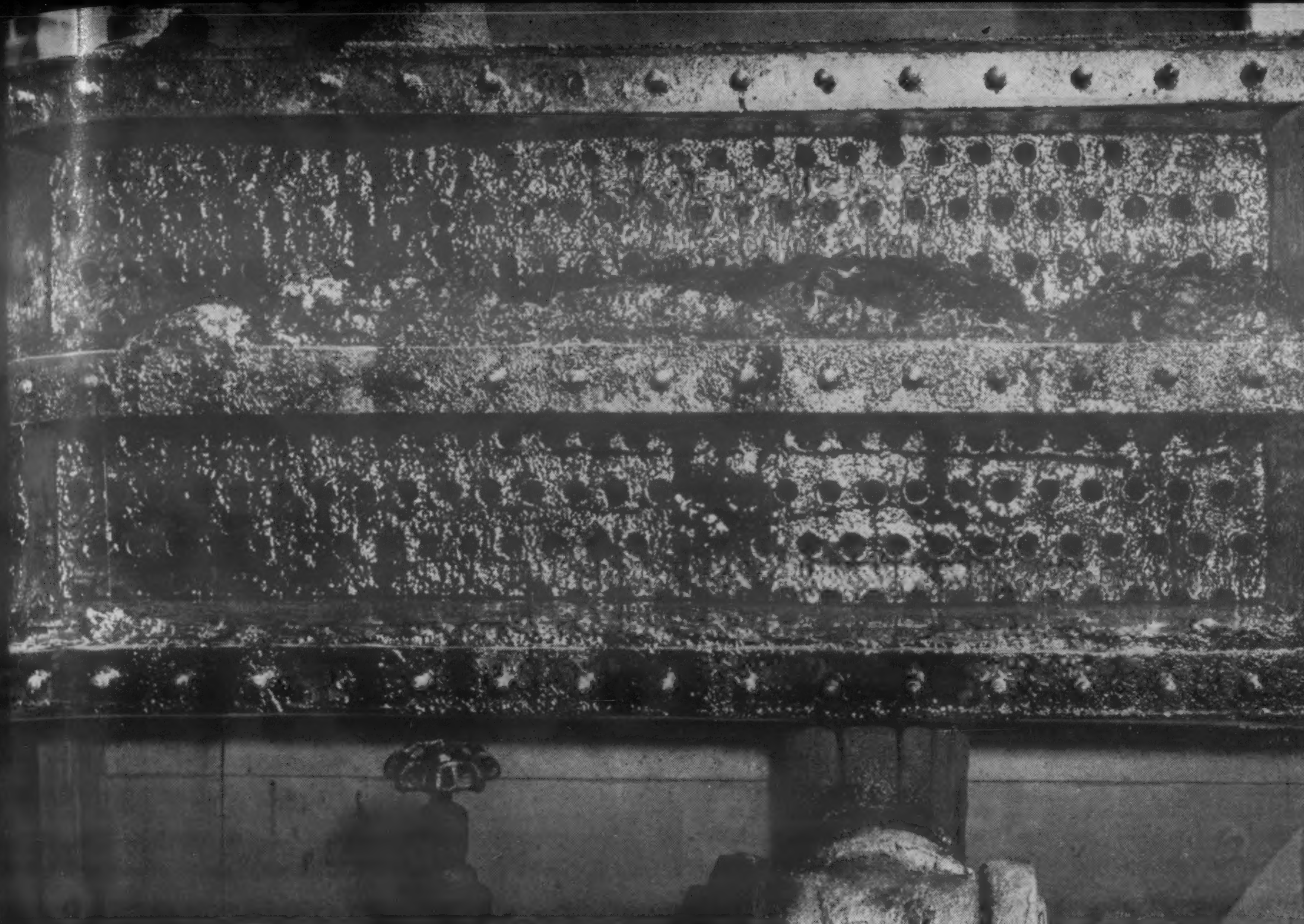
Following introductory chapters dealing with general principles and methods of control, individual chapters take up alloy plating, brass, cadmium, chromium, cobalt, copper, gold, indium, iron, lead, nickel, the platinum group, silver, tin, zinc, the uncommon metals and plating on aluminum and magnesium. Each chapter is organized on the same general pattern, giving principles, functions of constituents of the bath, operating conditions, maintenance and control, preparation of the basic metal, and finishing of deposits.

This book presents the details of commercially available processes and will be useful for both the chemist directly concerned with plating problems and the engineer faced with the task of installing such processes in his plant.

ORGANIC PROTECTIVE COATINGS. *Edited by William Von Fischer and Edward G. Bobalek. Reinhold Publishing Corp., New York 36, N. Y., 1953. Cloth, 6 by 9 in. 387 pp. Price $7.50.*

This volume is based on a lecture series sponsored by the Organic Coatings Div., Case Institute of Technology. The material included complements that covered in the earlier volume *Paint and Varnish Technology* but emphasizes the problems involved in a consideration of paint as an engineering material.

Eighteen authors have contributed chapters on their specialties. Several chapters present the theories of physics and chemistry as applied to coatings technology. Others offer typical case histories of progress in the coatings industry. These include the development of anti-corrosive pigments, hot spray lacquers, resin coatings for the protection of metallic surfaces, new applications of organic coatings to electrical insulation



Contents Noted | Books continued

and heat resistant paints.

The entire volume is orientated around the problem of paint formulation with full consideration given to the practical economic factors involved in selecting the proper coating for a specific application.

Organic Protective Coatings will be a valuable textbook for advanced courses in paint technology and a useful reference book for those engaged in the manufacture and use of coatings.

FORMULAS FOR STRESS AND STRAIN. *Raymond J. Roark. McGraw-Hill Book Co., New York 36, N. Y., 1954. Cloth, 6 by 9 in., 381 pp. Price $7.50.*

Here is a third edition of a practical handbook for engineers who are concerned with machine and structural design. The book can also be used as an auxiliary textbook for courses in stress analysis and elasticity. A few of the changes in this edition include: revision of experimental data and empirical formulas to bring them up to date; important new material added on sheer lag, stress and deflection of circular arches, flat plates with large deflection, pressure vessels and shells, and stress concentration; tables of coefficients for stress, deflection, and edge slope of flat plates; examples changed to illustrate the new formulas and afford comparison as between computed and experimentally determined stresses.

INDUSTRIAL INORGANIC ANALYSIS. *Roland S. Young. John Wiley & Sons Inc. New York 16, N. Y., 1953. Cloth, 6 by 9 in. 368 pp. Price $5.75.*

While this volume is written primarily for the industrial analytical chemist, it may also serve to acquaint the student with the technique and viewpoint of the industrial laboratory. Here, the author has accumulated a series of notes on analytical procedures, briefly giving the theory, separations necessary in a complex sample, and other useful and practical information.

SILICONES AND THEIR USES. *Rob Roy McGregor. McGraw-Hill Book Co., New York 36, N. Y., 1954. Cloth, 6 by 8 in. 302 pp. Price $6.00.*

For designers, engineers, and all who use silicones, this book gives an

Remington Rand Methods News

More Plants Slashing Maintenance Costs . . . Keeping Production At Peak

New Booklet On Preventive Maintenance Gives Flow Chart For Effective Control

Are *more than* 5 out of every 100 of your production workers doing plant maintenance? That's what a recent survey of manufacturing plants in the U.S. established! Is it any wonder that the latest developments in Preventive Maintenance Records, displayed at the Plant Maintenance Show held in Chicago in January, attracted sensational interest?

If you missed that exhibit, send today for our new free booklet X1383, showing in detail just how a planned maintenance control system works . . . how easy it is to install . . . how it insures maximum equipment productivity at greatly reduced operating cost.

These methods visually indicate what inspections are needed . . . permit scheduling of work ahead. Every man's time can be planned for maximum efficiency. Simplified visible methods provide tight control with paperwork streamlined to an absolute minimum.

The requirements of any such system are the same regardless of the size of the work force. They should include *all* of the following: 1) Written Work Orders 2) Scheduled Work 3) Equipment Records 4) Stores Control 5) Executive Reports.

Actually, maintenance management simply can't do a bang-up, cost-conscious job without a planned system with effective records providing all the facts for making sound decisions. The system offered in our booklet virtually gives you those facts at a glance!

Get this new booklet today. Study the flow chart showing effective Planning, Performing and Controlling of a Maintenance Program. See illustrations and descriptions of basic records which well-known plants are successfully using to put their maintenance operation on the same efficient basis as other operating departments. Ask for **X1383.**

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Let this Certified Report written by an official of the Timken Company show you why personnel records need to be kept indefinitely . . . how an ordinary file drawer which formerly held 3,000 to 4,000 letter size records, now holds 250,000 documents!

Further, how Kard-a-Film records filed under the Variadex system makes for such speed of filing and reference that Timken now actually locates a "dead" personnel record as easily and quickly as one in the active file!

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on a number of different microfilm spools. Documents no longer used can be kept up-to-date. Kard-a-Film Reader shows the records actual size right from the card and makes accurate inexpensive reproductions. Your personnel records are important to your company, your employees and others in your plant town get the benefit of Timken's experience. Get **CR867.**

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In sales analyses alone punched cards gave them a report that previously took 37 days, *in the amazingly short time of 3 days!* In the words of their chief accountant: . . ."it would have been difficult to operate with anything like our present efficiency, without these economical and *complete* accounting controls." See **Certified Report 804.**

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Contents Noted

Books continued

over-all picture of what silicones ar and the ways in which they can b used. The volume provides a corre lated source of the available informa tion on properties, preparation, and applications, treated as non-techni cally as possible. Types of commer cial products covered include silicon fluids, silicone compounds, silicon lubricants, silicone resins, silicon rubber, and "bouncing putty".

ALUMINUM WELDING, BULLETIN NUMBER 18. *Resistance Welde Manufacturers' Association, Phila delphia 3, Penna., 1953. 21 pp Price 25¢.*

This bulletin covers in detail th preparation of aluminum and alumi num alloys for welding, as well a giving the technical aspects of th welding process. Helpful diagrams tables and photographs are included

SYMPOSIUM ON TIN. *American So ciety for Testing Materials, Phila delphia 3, Penna., 1953. Paper, 6 by 9 in. 116 pp. Price $2.50.*

A Symposium on Tin was pre pared to give factual information on the only major common metal no covered by ASTM Specifications. Pre sented and discussed is compiled in formation on tin production and re sources, some of the major applica tions, certain examples of changes i technology to conserve tin, the effect of certain impurities, and the tech nology of analyzing for impurities.

EXPERIMENTAL METALLURGY. A. U *Seybolt and J. E. Burke. John Wiley & Sons, Inc., New York 16, N. Y. 1953. Cloth, 6 by 9 in. 340 pp Price $7.00.*

The principal objective of thi work is to describe most of the im portant laboratory techniques which are now used in the preparation o metals and alloy specimens for fur ther study. The preparation of meta samples up to the point of making observations on the properties o the metal is the guiding principle o this book. Hence, steps from prepa ration or selection of the base meta to be used through principles of al loying, melting without contamina tion, casting, fabrication into rod sheet, or wire, and heat treatment t obtain the desired structure, are in cluded.

(Continued on page 192)

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continued

STRESS CONCENTRATION DESIGN FACTORS. *R. E. Peterson. John Wiley & Sons, Inc., New York 36, N.Y. 1953. Cloth, 9½ by 11 in. 155 pp. Price $8.50.*

The purpose of this book is to give the designer information which will enable him to improve his design calculations to the end that failure will be less prevalent and better balanced designs will be achieved. The book should be regarded as a working tool; it is not intended as a text in the usual sense, and therefore only enough background and references are given to enable the reader to explore the subject further. Features have been incorporated to increase the book's usefulness—the edge finder, helical binding and the large, full-grid charts.

Reports

INVESTMENT CASTING OF SAE 104[illegible] STEEL (METHODS USED IN PREPARATION OF FATIGUE LIFE AND DECARBURIZATION TEST SPECIMENS). *U. S. Army Ordnance Corp. June 1953. PB 111199, 22 pp, with photographs and charts. Available from Office of Technical Services, U. S. Dept. of Commerce. $.50.* A research report presenting a practical manufacturing method of making investment castings in commercial carbon steels. This volume is an excerpt from a lengthy report on the investment casting study of the properties of these steels issued as Report PB 110463. It illustrates and outlines briefly the making of the master pattern, pouring of the bismuth mold halves, forming the expendable wax patterns, melting out the wax patterns and baking the investment mold, pouring the casting, shaking out the investment mold, and final sandblasting.

A STUDY OF ELASTIC AND PLASTIC STRESS CONCENTRATION FACTORS DUE TO NOTCHES AND FILLETS IN FLAT PLACES. *Herbert F. Hardrath and Lachlan Ohman, 1953. NACA Report 1117, 10 pp, diagrams. Available from the National Advisory Committee for Aeronautics, 1724 F St., N. W., Wash. 25, D. C.* Large aluminum alloy sheet specimens containing various notches or fillets were tested in tension to determin[illegible]

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their stress concentration factors in the elastic and plastic ranges.

INVESTIGATION OF SANDWICH CONSTRUCTION UNDER LATERAL AND AXIAL LOADS. *W. D. Kroll, L. Mordfin and W. A. Garland, Dec. 1953. NACA Bulletin TN 3090, 58 pp, ill. Available from the National Advisory Committee for Aeronautics, 1724 F St., N. W., Wash. 25, D. C.*

THE DIFFUSION OF LOAD INTO A SEMI-INFINITE SHEET. PARTS I AND II. *E. H. Mansfield, 1953.* In Part I, the rigorous and the "stringer-sheet" stress solutions are given for a point load applied in the plane of a semi-infinite sheet and at a finite distance from the boundary which is assumed to be free. From these are derived, by integration, some of the stresses produced by distributed loads applied along lines normal to the free boundary; attention is concentrated on the stresses along the line of action of the applied loads. The problem of finding the shear stresses adjacent to a load-carrying boom attached to the sheet and normal to the free edge is also investigated and integral equations for the shear stresses are derived. In Part II, a theoretical investigation is made into the problem of stiffening a sheet to relieve the high stresses near the free edge and adjacent to a direct load-carrying boom attached to the sheet. For booms of constant cross-section the stress distribution depends, with certain assumptions on two nondimensional parameters, and curves are included for determining the peak stresses in the sheet and the loads in the stiffening structure over the practical range of these parameters.

THE RELATIONSHIP BETWEEN THE CREEP AND TENSILE PROPERTIES AT ELEVATED TEMPERATURE OF NIMONIC 80 - II. *K. F. A. Walles and A. Graham, June 1953. 25 pp, diagrams, 3 tables.* The results of a few experiments on creep recovery enable the arguments of Report No. R. 100 to be extended. A new form of time-temperature variable is proposed which, without change of constants, satisfactorily coordinates N. P. L. and Mond-Nickel long-time creep data on Nimonic 80, N. G. T. E. short-time creep tests on Nimonic 80 drawn from store, and Mond-Nickel long-time data for an early heat of Nimonic 80A. Apart from this improvement, the situation previously


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Salts

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reported is not affected. Support is given for the Andrade formula for creep.

BRAZING AND SOLDERING OF TITANIUM AND ITS ALLOYS. *U. S. Army Ordnance Corps. January 1953. PB 111225, 117 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $3.00.* A report of the results of recent experiments in joining titanium workpieces, with special emphasis on the two important factors of developing maximum heat nearest the overlapping surfaces and of protecting them from harmful oxidation. It outlines the methods used to get such heat, as well as some of the improvement made in preventing the usual surface oxidation due to the high chemical activity of titanium with atmospheric oxygen. This report also describes and illustrates new techniques for making brazed joints with a torch, by electric resistance and in a furnace with inert gas atmosphere. There are also numerous drawings and photographs of the action, flow and strength of brazing fluxes used in making assemblies of titainum with titanium and various other metals.

WELDING; MOTION PICTURES — TECHNIQUES AND APPLICATION. *Sept. 1952. PB 111037, 29 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $.75.* Lists films for use in teaching special crafts, i.e., caring for and maintaining pipe lines with welding equipment, correct use of jigs and fixtures, control of tool supply in machine shops, recent advances in joining, bending, straightening, forming, and other metal shaping operations.

APPLICATION OF SILVER CHLORIDE IN INVESTIGATIONS OF ELASTO-PLASTIC STATES OF STRESS. *L. E. Goodman and J. G. Sutherland, University of Illinois, Nov. 1953. NACA TN 3043, 55 pp, diagrams, photographs, 4 tables.* Quantitative relationships between the state of elastic or plastic stress in a specimen and the observed relative retardation and extinction angle were developed from a general theory of stress birefrigence, according to a stress-dependent hypothesis. The relationships were verified experimentally by measurements on single-crystal specimens of silver chloride tested in simple tension in the elastic and plastic stress

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TYPICAL PROPERTIES

- **Weight loss of castings:**
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ranges. Studies were also made of stress states in bicrystal tension specimens, in simple polycrystalline tension specimens, and in single-crystal and polycrystal tension specimens with holes and notches. Silver chloride appears to be a suitable medium for photoelastic studies of effects of plastic yielding on the state of stress in a crystalline specimen.

RESISTANCE OF VARIOUS MATERIALS TO ATTACK BY MOLTEN BISMUTH-LEAD EUTECTIC AT ELEVATED TEMPERATURES. *James J. Gangler and Walter J. Engel. Sept. 1951. NACA RM E51F21, 14 pp, diagrams, photographs, 2 tables.* The resistance of 40 materials including alloys, ceramics, ceramals, and pure metals to attack by bismuth-lead eutectic at temperatures between 1500 F and 2000 F was investigated. A velocity of 15 ft per sec was maintained between the material surface and the bismuth-lead eutectic. Those materials found to be resistant to this attack included 17 of the ceramals and ceramics, graphite, and arc-cast molybdenum. All other materials investigated were appreciably attacked by the eutectic in the form of uniform attack, cavitation, or pitting, as indicated by metallographic analysis. No evidence of intergranular corrosion was observed in any of the materials studied in this investigation. Disintegration rates were estimated in mils per year from linear measurements taken before and after the specimens were subjected to attack by the molten eutectic.

EFFECT OF STRESSES AND THERMAL CYCLES PRESENT IN ARC-WELDED PLATE ON THE IMPACT PROPERTIES OF LOW-CARBON, ALUMINUM-KILLED STEEL, *by Thomas L. Robertshaw, June 1950, PB 110499, 39 pp. Available from Library of Congress. Publication Board Project, Wash. 25, D. C. Microfilm $2.25, Photostat $5.00.* The report deals with the results of an investigation of the poor impact properties found in low-carbon, aluminum-killed steel when introduced to conditions normally met in ½-in. plate during arc-welding. The effects of strain-aging, solution heat treatment, and strain hardening were studied separately.

TITANIUM BIBLIOGRAPHY, 1900-1951, *Charles A. Brophy, Beverly J. Archer, Robert W. Gibson and*

Library Bibliographic Section. Battelle Memorial Institute, Columbus, Ohio. 1952. PB 111196. 204 pp. Available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C. Mimeograph $3.00. 1952 Supplement is available as PB 111196s. 1953. 54 pp. Mimeograph $1.00.

STUDY OF CREEP OF TITANIUM AND TWO OF ITS ALLOYS. FOURTH PROGRESS REPORT, *July 1951 to September 1951, by W. R. Kiessel, J. V. Gluck, J. W. Freeman. University of Michigan Engineering Research Institute, Ann Arbor, Mich. PB 112228. 26 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, Photostat $3.75.*

AXIAL-LOAD FATIGUE TESTS ON NOTCHED AND UNNOTCHED SHEET SPECIMENS OF 61S-T6 ALUMINUM ALLOY, ANNEALED 347 STAINLESS STEEL, AND HEAT-TREATED 403 STAINLESS STEEL, *by Herbert F. Hardrath, Charles B. Landers and Elmer C. Utley, Jr. U. S. National Advisory Committee for Aeronautics. Oct. 1953. TN 3017. 28 pp. Available from NACA, 1724 "F" St., N. W., Wash. 25, D. C.*

BONDING MATERIALS, METALLIC MATING SURFACES LOW RF IMPEDANCE. *By Gary Steven. Armour Research Foundation, Chicago, Ill. June 1951. PB 109855. 6 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.25. Photostat $1.25.* This is Report #1 on bonding metallic and other materials including the mating surfaces involved, gaskets, and their electrical properties.

MATERIALS FOR HANDLING FUMING NITRIC ACID. PART 2: PROPERTIES OF FUMING NITRIC ACID WITH REFERENCE TO ITS THERMAL STABILITY. *By Mars G. Fontana. Ohio State University Research Foundation, Columbus, Ohio. Nov. 1952. PB 110963. 109 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $4.50, Photostat $13.75.* This report details corrosion tests on several metals and alloys in white and red fuming nitric acid at room temperature. The results of stress corrosion of Type 347 Stainless Steel, effect of additives to WFNA, and galvanic couple systems are reported.

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news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

A. L. Foscue has been appointed president of Electro Metallurgical Co. and United States Vanadium Co., divisions of Union Carbide and Carbon Corp.

R. A. Richards has been named manager, Bonding Materials Div., Bakelite Co.

Bart C. Dickey has been appointed process development engineer in the production department of Acheson Colloids Co.

Matthew J. Betley has been appointed vice president and general manager, Aeroquip Corp.

James E. Fifield has been named vice president and general manager of the newly reorganized Ductile Iron Foundry, Inc.

Henry D. Phillips, president, Hartford Electric Steel Co., will also serve as president, Ductile Iron Foundry, Inc.

John W. Pearson has been appointed executive engineer in charge of engineering research and development, Minnesota Mining & Manufacturing Co. Mr. Pearson will be in charge of engineering for staff laboratories, tape developments, chemical engineering, machine development, and instruments and controls.

Frederick L. Maltby has been appointed technical director in charge of all research, development and design facilities at Fielden Instrument Div., Robertshaw-Fulton Controls Co.

Dr. Samuel J. Nelson has recently joined the resins and plastics group, Research and Development Dept., Hooker Electrochemical Co. Previously Dr. Nelson worked on the preparation and application of polymers at U. S. Rubber Co., and was active in organic process development at Atlantic Refining Co.

D. W. Brown has been named to fill the newly-created post of manager of project engineering in the Piloted Aircraft Engineering Div., Goodyear Aircraft Corp. S. J. Pipitone has been appointed to succeed

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Mr. Brown as manager of airframe installations design.

Raymond Sellon, Jr. will head the newly formed Product Research Development Div., Stolper Steel Products Corp.

William O. Bosserman has been named managing engineer, Anodes Div., Sipi Metals Corp.

M. E. Dorman has been appointed manager of materials for the Canton Div., E. W. Bliss Co.

William O. Faxon has been elected vice president in charge of manufacturing, Metals Distintegrating Co. Previously Mr. Faxon had been works manager of the company's Harrison Abrasive Div.

Dr. Charles T. Molloy has been named manager of the newly created Physics Research Dept., at Vitro Corp. of America's laboratory.

Charles W. Punton has been made director of engineering, Mine Safety Appliances Co.

Sidney F. Kaufman has joined the Carboloy Dept., General Electric Co., as an engineer in the carbide powder processing and fabrication development unit.

Robert G. Nightingale has been appointed director of engineering for Wheeler Associates, Inc.

Robert F. Gager has been appointed director of Research, Snyder Chemical Corp.

Bernard N. Ames has been named general manager, Doran Manganese Bronze Co.

Richard P. Connette has been appointed to the post of assistant vice president, American Car and Foundry Co.

Leonard Shapiro has joined the staff of Titanium Alloy Manufacturing Div., National Lead Co., as senior chemist in the Research Dept.

Dr. Frederick W. Adams has been named director of research and development for the Millsplastic Div., Continental Can Co.

Milton L. Herzog has been appointed general manager of the Film Div., Olin Industries, and **C. E. Silk** has been named general manager of the company's new International Div.

Charles E. Heitman, manager of the Automotive Div., A. O. Smith Corp., has been named to fill the

◀ For more information, Circle No. 465

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newly-created post of assistant to the general manager.

Reid G. Fordyce has been promoted to the newly created post of director of development and technical service, Monsanto Chemical Co.'s Plastics Div. **Eli Haddad** and **Ivan Wilson** were named assistant directors of technical service.

William J. During has been named president, Precision Castings Co.

Gustave H. Froelich, vice president, The Torrington Manufacturing Co., has been named general manager of the company's Machine Div.

Raymond A. Erickson, formerly chief process engineer, Great Lakes Carbon Co., was recently appointed supervisor of chemical engineering at Armour Research Foundation, Illinois Institute of Technology.

Kermit D. Collom and **Stanley E. Jacke** have been appointed to the staff of the new Ultrasonics Div., Detrex Corp.

Ray Overholt, formerly director of the laminated plastics and metals Palmer Laboratory of United States Plywood Corp., has been named technical director of the Manufacturing Div., McMillan Laboratory, Inc.

Erwin W. Brown has been promoted to the position of division engineer for the electrical products group, Minnesota Mining & Manufacturing Co. Appointment of **William R. Ludka** as director of staff laboratories engineering was also announced.

news of COMPANIES

E. I. duPont de Nemours and Company will build a $3,000,000 laboratory in Wilmington to expand the present capacity of its Polychemicals Dept. Its facilities for providing engineering services, especially in the plastics field, will be several times those of the present laboratory at Arlington, N. J., which the new building will replace.

American Bosch Corp. has announced that construction has started on its new branch plant in Columbus, Miss. The new factory is scheduled for completion by April 1, 1954.

(Continued on page 208)

news of | COMPANIES

Seiberling Rubber Co. has announced that it has organized a new plastics division and that it is already in production on a pilot plant basis. Initially the division will concentrate on the fabrication of rigid plastics material with special properties of tensile strength, chemical resistance, or other desirable characteristics.

American Instrument Co. has erected a 40,000 sq ft plant at Savage, Md.

National Research Corp. has announced that all functions and departments of the Equipment Div. are now located at the Equipment Div.'s manufacturing plant at 160 Charlemont St., Newton Highlands 61, Mass.

General Electric Co. has announced construction of a new laboratory at Schenectady to help house its expanding activities in the fields of radioactivity and radiation.

Permutit Co. is building a modern metal working plant at Lancaster, Pa.

Vitro Manufacturing Co. has announced that it will merge with its two subsidiaries, **Vitro Corp. of America** and **Vitro Chemical Co.**, into one corporation. The merged corporation will be known as Vitro Corp. of America with offices in New York and will include five divisions. The resulting divisions will be: Vitro Manufacturing Co., makers of ceramic colors and chemical products, Pittsburgh; Vitro Uranium Co., Salt Lake City, processors of uranium ore; Canonsburg Rare Metals Co., Canonsburg, Penna.; Vitro Laboratories, Silver Spring, Md., and West Orange, N. J., engaged in research and development; and Vitro Engineering Div., New York.

Eutectic Welding Alloys Corp. has announced winners in the 1953 International $2000 Prize Competition devoted to "Technical and Research Aspects, Advances and Advantages of the Uses of Lower Melting (lower than parent) Filler Metals in the Non-Fusion Welding Process." Top winners were: Arthur Stuart Laurenson, Belmont Smelting Refining Works, Inc.; Ragnar Tidland of Svenska AB Gassaccumulator, Stockholm, and H. W. Sandford, United Aircraft Corp.; John Harrison Morton, Baltimore, Md.; George Gordon Musted, Sr., Birm-

news of COMPANIES

ingham, England, and Howard A. Hayden, Detroit.

WW Alloys, Inc., division of **Fansteel Metallurgical Corp.**, is the new name of the wholly-owned subsidiary formerly known as Weiger Weed & Co.

Westinghouse Electric Corp. will build a new metals development plant at Blairsville, Penna. Scheduled for completion by late 1955, the new plant will be devoted to metallurgical development and pilot production of special alloys and special castings. Westinghouse has also announced that engineering and other office personnel are moving into the new plant of the atomic equipment department located in Harmar Township approximately one mile northeast of the Allegheny Valley Interchange of the Pennsylvania Turnpike; the plant is part of the company's Atomic Power Div.

F. J. Stokes Machine Co. has organized a new Ordnance Division with its own integrated engineering and sales staff, to handle the company's large and growing ordnance equipment activities.

Latrobe Steel Co. recently held open house upon completion of its newest tool steel warehouse at Hillside, N. J.

The Dow Chemical Co.'s plant for the manufacture of vinyltoluene has been completed and is now in full production in Midland, Mich.

Lukens Steel Co. will build a $10,500,000 armor plate heat-treating plant and allied facilities on its property.

Three companies have united forces to expand the activities of the **Borolite Corp.** which was recently formed to pursue research and development of various metal borides for high temperature military and civilian applications, according to a joint announcement by the three companies: **Firth Sterling Inc., American Electro Metal Corp., The Carborundum** Co. The joint statement said the Borolite Corp. was formed to concentrate funds and facilities for the faster and broader development of new high temperature materials.

The General Ceramics and **Steatite Corp.** has announced the estab-

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lishment of an agreement with **Techno Ceramica, S.A.,** to supply technical knowledge for the manufacture of high frequency insulators in their plant at Sao Paulo, Brazil.

American Metal Products Co. and **Tube Reducing Corp.** have completed preliminary arrangements for a merger of the two firms on a stock for stock basis. The surviving corporation, American Metal Products Co., will continue to operate both businesses with separate corporate identities and with no changes in the present managements.

H. K. Porter Co., Inc. has acquired the **Alloy Metal Wire** Co., Prospect Park, Penna. Alloy Metal Wire Co. produces stainless and alloy steel wire, rod and strip for use in the electrical, electronic and chemical fields. Operations will continue as the Alloy Metal Wire Co., Division of H. K. Porter, Inc.

Polymer Industries has announced a new plant to be opened formally early in 1954. Located on a four acre site in Springdale, a suburban section of Stamford, Conn., it will consolidate the firm's Astoria and Brooklyn operations.

Foundry Services, Inc., have moved their head office to 260 Madison Ave., New York 16, N. Y.

Illinois Engineering Co., Chicago, has become a wholly owned subsidiary of **American Air Filter Co., Inc.,** Louisville, Ky.

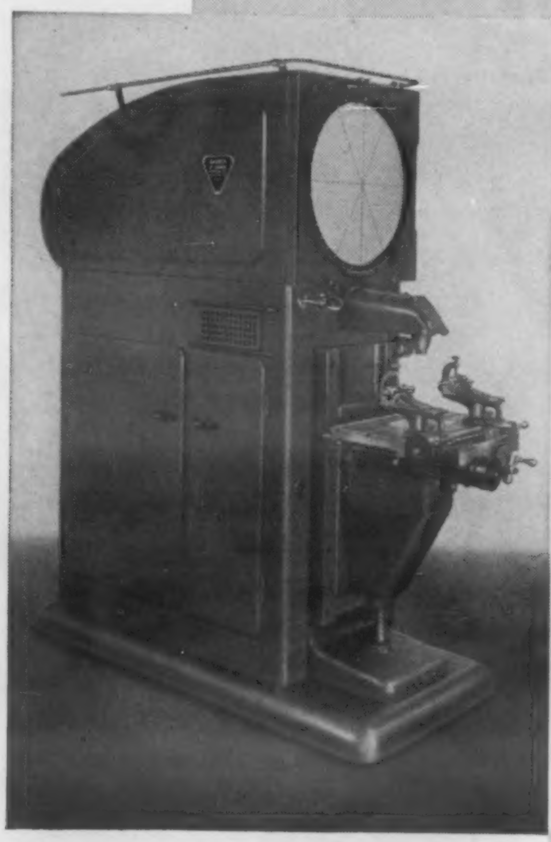
A. O. Smith Corp. has purchased **Glascote Products, Inc.,** a manufacturer of glass coated equipment for the chemical and chemical processing industries.

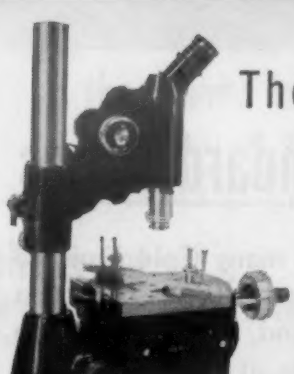
The **Sheaffer Pen Co.** has opened a new $1,500,000 tool and die plant at Fort Madison, Iowa.

United States Rubber Co. has acquired options to purchase a 90-acre tract of land in Preakness, Wayne Township, N. J., on which it plans to build a new research center devoted to research and development in the fields of rubber, chemicals, textiles and plastics.

The **Carborundum Co.** has announced that agreement has been reached for it to acquire the capital stock of **Stupakoff Ceramic and Manufacturing Co.** Stupakoff will continue operations under its present name and the present organization and personnel will be retained.

(Continued on page 214)





news of SOCIETIES

The **Standards Engineers Society** has announced the re-election of William L. Healy, General Electric Co., as president for 1954. Madhu S. Gokhale, RCA Victor Div., has been re-elected as vice-president.

The **Society of Automotive Engineers, Inc.** elected as its 1954 president William Littlewood, vice president for engineering, American Airlines, Inc. He succeeds Robert Cass of White Motor Co.

The **Pressed Metal Institute**, coincident with its 10th Anniversary Meeting, announced the appointment of R. W. Breckenridge as technical director in charge of the Institute's new technical and engineering department. Mr. Breckenridge was formerly president of Automatic Die and Products Co., Cleveland, and until this year was a member of PMI's board of directors.

American Society of Mechanical Engineers has announced the election of Lewis K. Sillcox, honorary vice-chairman of the board, New York Air Brake Co., as president. Mr. Sillcox succeeds Frederick S. Blackall, Jr., president and treasurer of Taft-Pierce Manufacturing Co.

Porcelain Enamel Institute has appointed James H. Giles, Jr., as its Research Fellow at the National Bureau of Standards. Before his appointment Mr. Giles was employed as a materials engineer with the Cement Reference Laboratory at the National Bureau of Standards.

Southwest Research Institute has announced that the first annual Judson F. Swearingen Award for outstanding scientific research work at the Institute has been won by John P. O'Meara and William L. Rollwitz. The two men were cited for their "pioneer work in nuclear resonance at low magnetic field strengths."

American Society of Tool Engineers has announced ten international education awards for 1954, nine in the United States and one in Canada, for full-time engineering students interested in pursuing tool and production engineering as a profession. Grants will be made effective with the school year beginning in the autumn of 1954 and will be paid directly to the institution on a quarter or semester basis to a total of $700 a year.

(Continued on page 216)

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. March 2-4, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, international meeting. Mexico City, D.F. March 10-12, 1954.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual conference and exhibition. Kansas City. March 15-19, 1954.

STEEL FOUNDERS' SOCIETY, annual meeting. Chicago. March 16-17, 1954.

PRESSED METAL INSTITUTE, annual spring technical meeting. Cleveland. March 17-19, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting. Chicago. March 29-31, 1954.

MALLEABLE FOUNDERS' SOCIETY, market development conference. Pittsburgh. April 8-9, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, spring aeronautical meeting. New York. April 12-15, 1954.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, spring meeting. Cincinnati. April 14-16, 1954.

AMERICAN ZINC INSTITUTE, annual meeting. St. Louis. April 20-21, 1954.

METAL POWDER ASSOCIATION, annual meeting. Chicago. April 26-28, 1954.

AMERICAN SOCIETY OF TOOL ENGINEERS, industrial exposition. Philadelphia. April 26-30, 1954.

ELECTROCHEMICAL SOCIETY, spring meeting. Chicago. May 2-6, 1954.

AMERICAN WELDING SOCIETY, exposition and national spring technical meeting. Buffalo. May 4-7, 1954.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Cleveland. May 8-14, 1954.

PORCELAIN ENAMEL INSTITUTE, midyear divisional meeting. Chicago. May 12-14, 1954.

BASIC MATERIALS EXPOSITION AND CONFERENCE, Chicago. May 17-20, 1954.

News Digest

Basic Materials Conference . . .

continued from page 6

Eastman Kodak Co.; John H. Garrett, Executive Director, Committee on Materials, Office of the Assistant Secretary of Defense for Research and Development; R. R. Gutteridge, Engineering Supervisor, Materials and Processes, Aeronautical Div., Minneapolis-Honeywell Regulator Co.; Julius J. Harwood, Head, Metallurgy Branch, Office of Naval Research, Department of Navy; Stuart S. Kingsbury, Piasecki Helicopter Corp.; W. E. Kingston, General Manager, Atomic Energy Div., Sylvania Electric Products, Inc.; Charles D. Leedy, Bendix Aviation Corp.; Walter A. Pollock, Supervisor, Engineering Standards, Vickers, Inc.; William W. Pratt, Weston Electric Instrument Corp.; John B. Seastone, Westinghouse Electric Corp.; W. A. Stadtler, Manager, Technical Services Laboratory, International Business Machines Corp.; F. F. Vaughn, Caterpillar Tractor Co., and R. A. Wenneker, Chief Materials and Processes Engineer, McDonnell Aircraft Corp.

Advance registration cards for the Materials Show may be obtained from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

Brother Jeep **The new featherweight "Aero Jeep" shows itself off next to the Army's famed standard Jeep. Jeep-producer Willys Motors, Inc., developed the "Aero" to meet the demands of mobility of modern warfare including airborne operations by helicopter or air transport. The new model is 1200 pounds lighter, three feet shorter, than its "older brother," but retains the latter's versatility and ruggedness over rough terrain and has 85 per cent interchangeability of parts. Army Ordnance has just completed intensive testing of the vehicle at Aberdeen Proving Ground.**

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Welded Tubing

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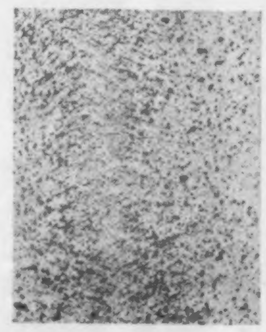
Samples of induction welded non ferrous tubing compressed and expanded to show weld strength.

formly narrow weld zone with a grain structure minimally affected by heat (see micro).



Weld zone section 14S-O Al. tube. Approx: 35X

Physical tests on type 304 stainless steel, according to the Yoder Co., show that tensile strength of the weld zone metal is about 15% over that of the coiled strip. Similar results are claimed for nonferrous metals, which show consistent weld strength.

After the tube is welded in the mill, it passes through trimmer knives which remove inside and outside flash. Six sizing rolls resize the tubing for diameter and circular shape before it is cut to desired length by a flying saw synchronized with the speed of fabrication.

An important new use for the continuous tube forming mill is seen in adapting the process to fabrication of aluminum cable sheathing. The process combines high speed and continuous forming to any desired length. The cable can be fed into the mill simultaneously with the strip, which is formed around it and welded without injury to even paper or rubber insulation. The process results in a snug fit in one pass, eliminating operations such as pulling the cable through the tubing and rolling it to a snug fit.

The Yoder Co. has supplied nonferrous welded tubing mills to the Aluminum Co. of America, Bridgeport Brass, and the Navy, in addition to the Kaiser mills mentioned above.

(Continued on page 222)

You're missing something if you overlook

CRUCIBLE HOLLOW TOOL STEEL

If you make tool steel parts with machined-out centers, don't overlook the many benefits of using Crucible Hollow Tool Steel.

It eliminates drilling, boring, cutting-off and rough facing operations. Naturally, this cuts overall production time, steps up machine capacity and reduces scrap losses. Many manufacturers have been able to cut material costs alone by as much as 20% when they use Crucible Hollow Tool Steel instead of regular bar stock.

Crucible Hollow Tool Steel is available in three famous grades: KETOS oil hardening, AIRDI 150 air hardening, and SANDERSON water hardening tool steels. We supply it with machine finished inside and outside diameters and faces — cut to your specific length requirements. And no steel producer can assure you of more uniform quality. For we have complete control over every phase of manufacture and distribution.

For more information, call the Crucible warehouse nearest you . . . or write for new brochure describing Crucible Hollow Tool Steel. Address Crucible Steel Company of America, Dept. MM, Oliver Bldg., Pittsburgh 22, Pa.

CRUCIBLE first name in special purpose steels

54 *years of Fine steelmaking*

HOLLOW TOOL STEEL

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For more information, turn to Reader Service Card, Circle No. 447

News Digest

Government Backs Titanium Boost

Titanium production is due for a bigger boost as a result of the recent Senate Strategic Materials Subcommittee hearings. Testimony of representatives of the Air Force and aircraft manufacturers convinced the lawmakers that future supply of the metal will fall far short of demand (see M&M January News).

$75 Million Expansion

Final Senate subcommittee recommendations led the Defense Mobilization Board to approve a titanium plant expansion program amounting to $75 million and to place a standing order with GSA to increase titanium facilities at the rate of 20,000 tons capacity per year. Contracts to be placed within the next three months for additional facilities will offer such juicy incentives as cash advances against future production, market guarantees, and fat tax deductions for rapid plant amortization.

Another subcommittee recommendation now being carried out is the establishment of a top-level board of experts to expedite titanium procurement in conjunction with the needs of the Air Force, Navy, Army Ordnance and industry.

Current Production

At present, the Government has placed contracts for Kroll process installations capable of producing only 13,000 tons of titanium annually. However, 6000 tons of the total is accounted for by a recent contract with the Crane Co., which will not produce sponge at capacity until late 1955 or 1956. Total 1953 titanium production amounted to a scant 2400 tons.

Before the new order, the General Service Administration had been authorized to contract for titanium facilities of 25,000 tons annual capacity, but had not placed contracts for the balance of the amount over 13,000 tons. The delay in expediting contracts for full authorized capacity stems from several factors. The original Defense Dept. estimate for titanium needs called for annual production of 35,000 tons, but this

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goal was slashed back by budgetary considerations to 25,000 tons. Thus a rather unfavorable political climate prevailed against rushing into the first contracts that could be let for producing the metal. Another, and stronger factor in the delay was that the Kroll process, the only way to produce titanium commercially, is not only incredibly expensive, but also presents immense difficulties in quality control. For instance, the ASTM has been unable to determine a satisfactory standard for titanium sponge due to the difference between the products of the only two producers. Among potential manufacturers, a general attitude exists that a better and cheaper method for producing titanium will come out of the nation's metallurgical laboratories, and that the expensive vacuum furnace equipment necessary for volume Kroll process production will be made prematurely obsolete.

Outlook for Future

The prospects for a new process still seem to be in the distant future, however, and the insistence of the aircraft industry on the immediate and pressing need for greater supplies of the metal has resulted in the decision to get titanium at any cost—an order that might be compared to a demand for large volume production of aluminum without the electrolytic refining process.

With losses underwritten and markets guaranteed, it is likely that more companies will be signing up for titanium production in the very near future—but satisfactory volume is a long way off and price reductions for the metal are even farther in the future.

Plastics Have Record Year

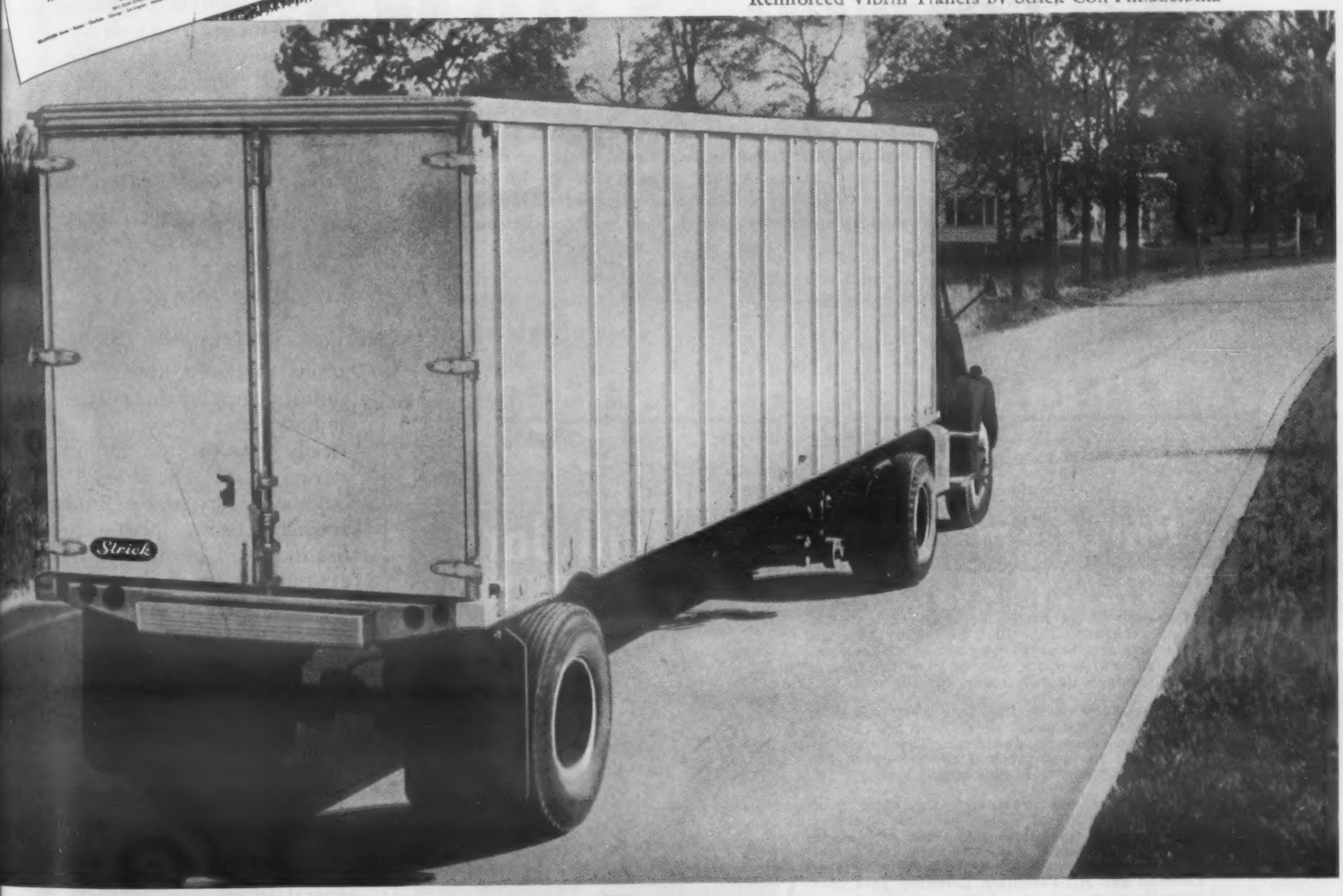
The plastics industry, looking back on a 1953 record year that registered a 30% volume gain over 1952, forecasts that the 1954 activity in plastics will maintain the general level of 1953 after a slight decrease in activity during the early months of this year.

(Continued on page 226)

and now...Vibrin

Plastic Trailers!

Reinforced Vibrin Trailers by Strick Co., Philadelphia



Less than two years ago, Naugatuck first announced a dent-proof, rust-proof **car body** of Vibrin polyester and glass fibers. Now this amazing reinforced plastic is being used to construct heavy-duty **truck trailers!**

Strong yet light! Riveted to a light metal skeleton, Vibrin glass-fiber panels are unharmed by severe impacts of loading, unloading, and road shock. They won't warp, shrink, or lose their fit. They eliminate heat-leaking joints in refrigerated trailers. **And they save up to 1000 lbs. in weight!**

Extremely **corrosion-resistant!** Vibrin trailer bodies can't rust—won't rot, become contaminated, or swell, even under steam cleaning.

Translucent, too! Unpigmented roof panels allow enough light to read shipping labels—**make loading and unloading far easier!**

No wonder more and more manufacturers everywhere are swinging to Vibrin. In boat hulls, auto bodies, machine housings, structural paneling, and many other applications, it's leading the way to newer, finer, more efficient products.

Why not reinforced Vibrin® for milk and ice cream carriers, box car interiors, house trailers, storage refrigerators—**wherever** corrosion or leakage poses a problem? See how this singularly strong, light, and corrosion-resistant plastic material can put **you** on the road to profits.

For further information write on your letterhead to the address below.

Naugatuck Chemical

Division of United States Rubber Company

12 ELM STREET, NAUGATUCK, CONNECTICUT

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario

News Digest

The outlook for a more or less static year, as far as total volume is concerned, is seen as the resultant of two opposing trends. The general growth nature of the plastics industry, with its expanded facilities, and the increased number of uses of plastics in new products will encourage continued expansion. Offsetting this general long range trend, some retrenchment, inventory readjustment, and reduction in production volume of specific items (such as television and radio cabinets) should about even off the record and keep the plastics industry close to, if not slightly below, 1953 levels.

Steady Growth Cited

The Society of the Plastics Industry points out that the industry is still basically in a growth situation but "it has had brief periods of recession before and it can have them again." In terms of the volume of synthetic resins produced, the records of the industry support this contention. The industry has enjoyed a period of steady growth that might well be envied by any general field. Throughout the history of the production of synthetic resins, plastic production has increased steadily, with only five of the last thirty years registering decreases compared to the preceding year. Synthetic resin production in 1922 totalled only slightly more than 2900 tons, while in 1953, 1½ million tons were produced. This total represents a gain of more than a quarter of a million tons over 1951, the next highest year on record. While production in 1952 dropped from 1951, the industry came back with a will in 1953 to score a 30% general increase in breaking its all-time record for production volume of synthetics.

Recent price cuts in many important plastic materials indicate that plastics will be increasingly attractive to design engineers from a cost standpoint. Polyethylene prices have dipped three times in the last year, and production of the tough material is due for heavy increases both from companies in the field and from new entrants. Shortly after the first of the year, Bakelite reduced prices of its phenolic molding plastics 1½ to 2¢ per pound, which brought the price of its chief large volume phenolic plastic down to 19¢ per pound. At the same time, Reichhold Chemicals announced a three cent reduction in

For more information, turn to Reader Service Card, Circle No. 488

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its line of polyester resins for use with glass fibers to make building panels, auto bodies, and other reinforced products. This reduction puts the price of this polyester at 35 to 36¢ per pound compared to 38 to 39¢ formerly.

Production and consumption of plastic molding material was up an estimated 28% over 1952, which was in itself a good year for the industry. Phenolic molding material showed the highest increase, scoring a gain of nearly 50%, with polystyrene up 43%, cellulostic up 41% and vinyl up 20%. Miscellaneous molding materials, a category including polyethylene, nylon and acrylics, increased 36% over the previous year.

Competition between the many companies identified with the plastics industry will get more intense in 1954. The pattern of mergers and outright purchases of plastics concerns by companies in the plastics industry as well as by outside organizations seeking an entry into the field will probably continue this year. Production of plastic pipe by metal fabricators in order to round out their line of products may be expected to increase.

The SPI estimates that from 5000 to 6000 companies identified with the plastics industry throughout the U. S. employ around 200,000 persons in plastic work. These companies include: molders; extruders; laminators; reinforced plastic product manufacturers; film sheeting and coated fabric processors; fabricators; raw material suppliers; machinery and equipment manufacturers; tool, die and mold makers; research and development laboratories and others.

Areas in the plastics field that seem to be headed for further rapid increases this year according to statements by men in the business include plastic pipe, and reinforced plastics. Increased consumer and retailer acceptance of plastic items is expected to increase as a result of intensive campaigns to establish quality standards sponsored by the Society of the Plastics Industry and issued by the Department of Commerce. Better product design, improved materials and the proper use of the right materials has restored a great deal of the faith in plastics that was lost in the past through improper use.

The synthetic fiber makers broke into 1954 with some significant price

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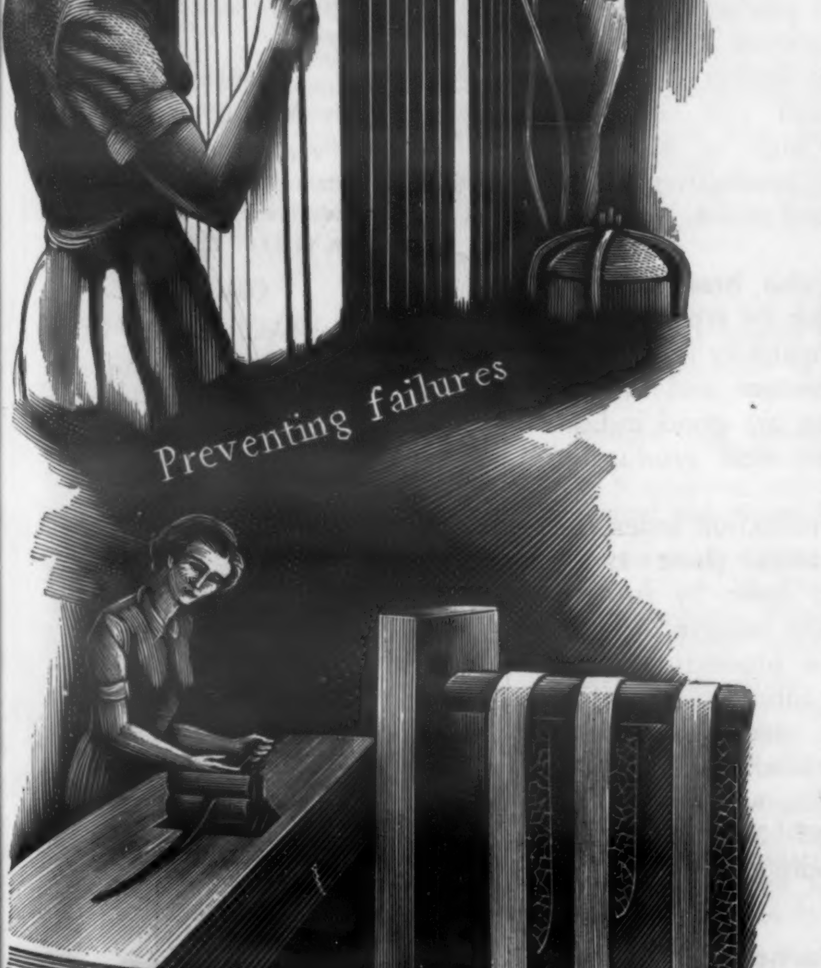
reductions that may herald the beginning of a whole series of price reductions in the fiber field. Du Pont started the ball rolling with a 10¢ slash in Orlon prices. Chemstrand's Acrilan, a similar fiber, was promptly reduced 45¢ per pound, which made some users in the field predict that a further reduction in the price of the du Pont fiber would be forthcoming. The textile companies, in their hotly competitive market, are expected to pass the price reductions right down to the consumer. The bedeviled wool industry will suffer further inroads on its markets as a result of these cuts, and will have to go along pricewise even though the volume of synthetics is less than 20% of the wool consumption. Again, the general growth nature of the synthetic resin industry is probably the most significant factor in the long range price and inter-material competitive situation.

AISI Adopts Steel Production Index

The American Iron and Steel Institute has adopted an index for steel production based on ingot tonnages during the years 1947-1949. The Institute feels that the index, in addition to the usual weekly percent of current rated capacity production, will give a better long range perspective on the trend of steel activity.

The average annual ingot and casting steel production rate for the three years on which the index is based was 83,837,572 net tons, a rate considerably above annual production of pre World War II years. The base period was chosen particularly in order to jibe with several new government indices that have been revised to post war standards. Thus the index permits a direct comparison of steel activities with other production, cost and sales records complied by the Departments of Census and Commerce.

The current operating rate of the steel industry will continue to be measured by the percent of weekly capacity based on the annual capacity of the steel industry on January 1. Capacity this year is 124,330,410 tons, a rise of nearly seven million tons since January 1953, and about



A higher priced adhesive can often save you money

One of the many new adhesives now available may offer you possibilities for attractive savings through faster production, fewer rejects, and increased customer satisfaction. The little extra this improved adhesive may cost you can well become a very profitable investment.

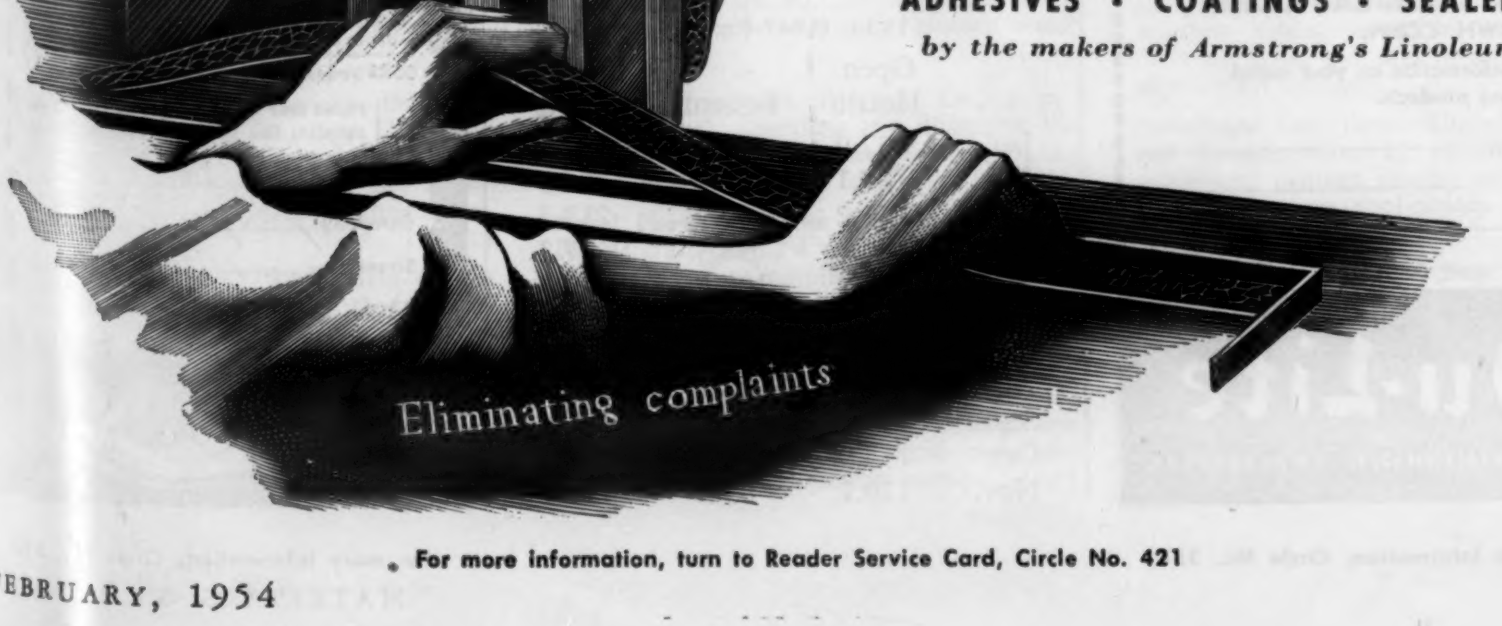
For example, by switching to a new Armstrong's Adhesive, makers of linoleum-topped desks reduced failures on radius edges almost to zero. In another case, a new, extra-flexible Armstrong's Adhesive solved a difficult bonding problem in the production of folding vinyl doors. Belt manufacturers find adhesives faster than sewing—and adhesive-bonded belts last longer and cause fewer complaints.

If you'd like one of Armstrong's adhesives specialists to help you find possible savings in your plant, call or write Armstrong Cork Co., Industrial Adhesives Dept., 8002 Dunbar St., Lancaster, Pa. In Canada, 6967 Decarie Blvd., Montreal.

ARMSTRONG'S

ADHESIVES · COATINGS · SEALERS

by the makers of Armstrong's Linoleum



For more information, turn to Reader Service Card, Circle No. 421

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16 million tons above 1952 rated capacity. The new weekly figure, on which the weekly operating rate of the industry is based in American Iron and Steel Institute reports is 2,384,549 net tons of ingots and steel for castings. This new weekly capacity is 130,090 tons greater than that of 1953.

The annual capacity of the nation's steel industry has increased more than 32 million tons in the eight post war years, or about 35%. The increase assumes even greater significance alongside comparative foreign yardsticks. For instance, additions to the nation's steel capacity in the last eight years alone are nearly equal to the total USSR steel industry capacity.

1954 production capacity is equivalent to 148 on the steel production index. Last year's production record, 95% of 1953 annual capacity, or 111,650,000 tons, makes the index for 1953 a record 134 compared to the previous high of 125.5 in 1951. The 1952 production index, because of the steel strike, was only 111.1.

The index is also broken down for steel production by types of furnace, and the comparative indices for open hearth, Bessemer and electric furnace production are good indicators of trends in steel production methods.

The monthly production index for 11 months of 1953 (base 1947-49=100) broken down by furnace type shows both the relative increase in electric furnace production since 1947-9, and the inherent flexibility in that type of steel production. Electric furnace production ranged 96 points on the index, while Bessemer production ranged 20, and open hearth only 11 points.

Index for Furnace Types

1953 (1947-9=100)

	Open Hearth	Bessemer	Electric
Jan.	137.9	99.6	197.1
Feb.	137.1	103.7	205.3
Mar.	141.2	100.9	213.3
Apr.	136.9	98.3	207.3
May	139.2	100.8	200.7
June	135.3	97.6	196.0
July	129.7	92.1	177.7
Aug.	132.0	88.2	176.9
Sept.	130.2	84.5	150.2
Oct.	134.9	92.5	136.8
Nov.	129.1	83.3	117.0

MANUFACTURERS' LITERATURE

Industrial Paint. Rust-Oleum Corp., 20 pp, No. 253. Catalog contains 94 color chips of rust preventative and surface protecting paints. (52)

Fasteners. Southco Div., South Chester Corp., 24 pp, No. B2. Discusses fastening specialties, including screws, blind rivets, spring-grip fasteners, etc., tables included. (53)

Bi-Metallic Construction. Arthur Tickle Engineering Works, 8 pp, ill. Description of Alumibond process for molecularly bonding aluminum and its alloys to iron and steel and their alloys. (54)

Testing Equipment. Tinius Olsen Testing Machine Co., 8 pp, ill, No. 1053. Description of various lines of mechanical and electrical testing machines. (55)

Cadmium Plating. The Udylite Corp., 6 pp, No. CDT-53. Technical data and description of cadmium plating process. (56)

Other Available Literature

Irons and Steels • Parts • Forms

Steel Weldments vs. Castings. Acme Tank & Welding Div., United Tool & Die Co., 20 pp, ill. Booklet furnishes basic facts about steel plate fabrication as compared to casting for manufacturers and designers of heavy machinery, equipment, service apparatus and components. (59)

Metal Products. Allied Metal Specialties Inc., 4 pp, ill. Illustrates a variety of trays, racks, fixtures, tanks, crates, baskets, etc. produced by this company. (60)

Precision Castings. Austenal Laboratories, Inc., Microcast Div., 16 pp, ill. Describes Microcast Process for manufacture of precision cast parts, including specifications and explanation. (62)

Welded Steel Tubing. Avon Tube Div., 11 pp, ill. Gives advantages, specifications of Fusionweld steel tubing and illustrates uses and applications. (63)

Tool Steel. Bethlehem Steel Co., 28 pp, ill, No. 343-536. Oil and air hardening tool steels. Properties and instructions for working 6 steels. (64)

Wire Cloth, Belts. Cambridge Wire Cloth Co., 140 pp, ill. Revised catalog giving data on wire mesh conveyor belts, including applications and specifications. (66)

Straight Chromium Stainless Steel. Carpenter Steel Co., 4 pp, ill. Advantages of using Carpenter Stainless No. 3 (Type 443) straight chromium stainless steel. (67)

Stainless Steel Tubing and Pipe. Damascus Tube Co., 8 pp, ill. Profusely illustrates the manufacturing process of stainless steel tubing and pipe offered by Damascus. (68)

Custom Steel Parts. H. Disston & Sons Inc., 16 pp, ill. Describes custom steel parts, how they are made and how to use and order them. (69)

Forged Metal Quality. Drop Forging Assn., 6 pp, ill. Detail of several hot working processes emphasizing improvements achieved in metal structure using these processes. (70)

Springs, Wire Forms, Stampings. Dudek & Bock Spring and Mfg. Co., 3 pp, ill. Shows springs designed in coil, wire forms and metal stamping forms designed and manufactured to meet specification requirements. (71)

Steel Castings. Farrell-Cheek Steel Co., 4 pp, ill, No. 40. Examples of the intricate electric furnace carbon and alloy steel castings produced by this company. (72)

Metal Hose and Instrument Bellows. Flexonics Corp., 16 pp, ill, No. CMH-123R. Data on flexible metal hose and Flexon bellows, including specifications. (73)

Hardness Conversion Tables for Steel. International Nickel Co., Inc. A celluloid card, wallet size, gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steel. (74)

Tools and Dies. B. Jahn Mfg. Co., 16 pp, ill. Profusely illustrates the facilities of this company for producing production-proved tools and dies. (75)

Stampings. Laminated Shim Co., Stampings Div., 12 pp, ill. Describes facilities for producing good quality stampings to specifications, facts to be considered in ordering stampings and other data. (76)

Centrifugal Steel Castings Data. Lebanon Steel Foundry, 8 pp, ill. Describes centrifugal casting process for producing many symmetrical steel shapes at low cost with great accuracy. (77)

Pressed Parts. Lenape Hydraulic Pressing and Forging Co. Catalog shows numerous parts press formed by this company, illustrating the kinds of jobs this firm can perform. (78)

Flanged and Dished Heads. Lukens Steel Co., 2 pp, ill, No. 606. Features stock list of a complete line of ASME and standard flanged and dished heads. (79)

Ductile Iron Castings. Lynchburg Foundry Co., 12 pp, ill. Describes ductile cast iron with detailed description of its properties and suggested applications. (80)

Welded Assemblies. The R. C. Mahon Co., 1 p, ill. Shows several examples illustrating the capabilities of welding for construction of various assemblies. (81)

Sheet Metal Products. Maysteel Products Inc., 10 pp, ill. Illustrates Maysteel's standard and specialized tools for producing sheet metal parts and shows some of the industries served by their products. (82)

Metal Castings. Myerstown Foundry & Machine Works, 20 pp, ill. Stock list of a complete line of ready-made Momex metal castings. (83)

Forgings. Pittsburgh Forgings Co., 8 pp, ill, No. 5200. Describes and illustrates the facilities of this company for producing drop, press and upset forgings. (85)

Metal Powder Machine Parts and Bearings. Powdercraft Corp., 4 pp, ill. Detailed specifications of a complete line of Powdercraft self-lubricating bearings and machine parts produced by powder metallurgy. (86)

Metal Containers. Pressed Steel Tank Co., 16 pp, ill. Tells how many industries have been helped in quality production at low cost by use of Hackney Metal containers and deep drawn component parts. (87)

Steel Wire Rope. John A. Roebling's Sons Co., folder, ill. Describes the manufacture of steel wire rope from the manufacture of the steel through to the finished rope. (88)

Industrial Spring. Sandsteel Spring Div., Sandvik Steel Inc., 10 pp, ill. Informative, nontechnical outline of facilities and types of products engineered and manufactured by Sandsteel. (89)

Stainless Steel Products. Schnitzer Alloy Products Co., 48 pp, ill, No. 50. Specifications and corrosion data on such stainless products as machine screws, nuts, pipe and tubing. (90)

Precision Castings. Sessions Foundry Co., 8 pp, ill. Presents design and engineering data on Hyprecision castings. (91)

Carbon and Low Alloy Steel Castings. Steel Founders' Society of America, 20 pp, ill. Reprint discusses the properties, specifications, design, joining, heat treating and inspection of carbon and low alloy steel castings. (92)

Fine Small Tubing. Superior Tube Co., 4 pp, ill, No. 32. Detailed information on Superior fine small tubing in all analyses 0.10- to $\frac{5}{8}$-in. o.d. and in certain analyses (9.935-max wall) up to $1\frac{3}{8}$-in. o.d. (93)

Steel Forgings. Titusville Forge Div., Struther Wells Corp., 8 pp, ill. Describes facilities for precision forging of parts regardless of size, metal or alloy. Shows numerous parts produced. (94)

Stainless Tubing. Trent Tube Co., "Trentweld Data Bulletin" describes Trentweld stainless steel tubing, machine formed and welded in wide range of sizes. (95)

Compression-Formed Tubing. Tube Reducing Corp., 8 pp, ill, No. R-3. Specifications, description and method of making steel compression-formed tubing included. (96)

Tool and Die Steels. Uddeholm Co. of America Inc., 28 pp. A handy stock list containing a complete line of tool and die steels and specialty strip steels produced by this company. (97)

Fine Seamless Tubing. Uniform Tubes, 4 pp, ill. Covers a complete line of fine seamless tubing available in sizes from 0.10- to $\frac{5}{8}$-in. o.d. and in metal of almost any desired analyses. (98)

Centrifugal Cast Parts. United States Pipe and Foundry Co., 12 pp, ill. Describes centrifugal castings process and advantages, and shows three applications improved by this method. (99)

Stainless Steel Sheet and Strip. Washington Steel Corp., 4 pp. Includes types, uses, physical properties and specifications of MicoRold stainless steel sheet and strip. (100)

Flanged and Dished Heads. Wickwire Co., 130 pp, ill. Comprehensive information and engineering data on C F & I flanged

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and dished heads, flueholes, handholes, saddles, etc. (101)

Non-Slip Steel Plate. Alan Wood Steel Co., 8 pp, ill. Specifications and characteristics of Algrip abrasive rolled steel floor plate designed for non-skid applications. (102)

Screw Machine Parts and Other Metal Forms. Worthington Corp., 7 pp, No. W-350-B5C. Describes valves, flanges, hose nipples, bars, welding electrodes and screw machine products available. (103)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, ill. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (104)

Nonferrous Metals • Parts • Forms

Die Castings. The Accurate Die Casting Co., 24 pp, ill. Shows company's facilities for producing to order all types of zinc and aluminum die castings. Includes table of alloy properties. (137)

Die Castings. Advance Tool & Die Casting Co., 8 pp, ill. Illustrates facilities of this company to produce die castings to specifications. (106)

Bronze Alloys. American Manganese Bronze Co., Rhawn & Torresdale Ave., Philadelphia, 46 pp. Data on properties and specifications of bronze alloys for casting. Request direct from company on business letterhead.

Magnesium Castings. American Radiator and Standard Sanitary Corp., 8 pp, ill, No. 377. Illustrates the facilities of this company for producing magnesium sand molded castings. (107)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (108)

Aluminum Bronze Die Castings. Aurora Metal Co., 8 pp, ill. Description, advantages and sample products of firm's vacuum die casting process. Technical details of alloys used. (109)

Beryllium. Brush Beryllium Corp., 4 pp, ill. Uses of beryllium and its alloys and compounds. (105)

Copper-Base Alloys. Bridgeport Brass Co., 4 pp. Compositions, properties, forms and typical uses of 65 commonly used copper-base alloys useful to users of copper alloys. (110)

Bronze Bar Stock and Bearings. Bunting Brass & Bronze Co., 72 pp, ill, No. 52. A complete presentation of this company's standard stock bearings, graphited Oilless bearings, precision bronze bars and electric motor bearings. (112)

Magnesium Forms. Dow Chemical Co., Magnesium Div. Technical information on magnesium, its available forms and applications. (113)

Investment Castings. Electronicast Inc., 4 pp, ill. Features specifications of the Electronicast process of centrifugal and vacuum investment casting for casting difficult alloys in intricate shapes and to extremely close tolerances. (114)

Contact Rivets. Gibson Electric Co., 6 pp, ill, No. C-521. Description and specifications of a complete line of Gibson electrical contact rivets. (115)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (111)

Aluminum Extrusions. Harvey Aluminum Div., Harvey Machine Co., 8 pp, ill. Properties, characteristics and application of a variety of aluminum extrusions produced by this company. (116)

Nickel-Base Alloys. Haynes Stellite Div., Union Carbide and Carbon Corp., 40 pp. Properties, specifications and uses of Hastelloy corrosion resistant grades. (117)

Laminated Metals. Improved Seamless Wire Co., Inc., 6 pp, ill. Describes the importance and applications of laminated metals to modern industry. (118)

Centrifugal Castings. Janney Cylinder Co., 25 pp, ill. Describes wide variety of finished machined centrifugal castings available. Lists alloys and their properties and types of products. (119)

Die Castings. Litemetal DiCast, Inc., 12 pp, ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (120)

Tungsten Carbide Parts. Metal Carbides Corp., 68 pp, ill, No. 52-G. Description, specifications and prices of standard Talide Metal dies, rolls, bushings, forms and special shapes. (121)

Screw Machine Parts. Mueller Brass Co., 6 pp, ill. Shows brass, bronze and copper custom-made screw machine parts available, and lists other nonferrous products. (122)

Nonferrous Die Castings. The New Jersey Zinc Co., 28 pp, ill. Applications and principal features of Zamak-3, and Zamak-5 zinc alloy die castings. (123)

Die Castings. Racine Die Casting Co., 8 pp, ill. Zinc or aluminum castings of various sizes illustrated with facilities for their manufacture. (124)

Titanium and Its Alloys. Republic Steel Corp., 32 pp, ill, No. 588. A practical working manual presenting some basic and fairly well substantiated data on commercial quality titanium and its alloys. (125)

Condenser Tubes. Revere Copper and Brass Inc., 28 pp, ill. Detailed discussion of ways to make condenser tubes last longer, what they are made of, and new developments in materials. (126)

Centrifugal Castings. Shenango-Penn Mold Co., Centrifugal Castings Div., 6 pp, ill, No. 150. Profusely illustrates a variety of types and sizes of nonferrous centrifugal castings produced by this company. (127)

Aluminum and Magnesium Sand Castings. South Gate Aluminum & Magnesium Co., 12 pp, ill. Features the facilities of this company for producing precision aluminum and magnesium sand castings and precision machined parts. (128)

Spun Metal Parts. Spincraft Inc., No. 3. Data book on metal spinning and fabricating gives data on process and help in designing for economical production. (129)

Magnet Wire. Sprague Electric Co., 4 pp, ill, No. 404. Complete data on Ceroc ST, a single-teflon, ceramic insulated high temperature magnet wire. (130)

Light Metal Castings. Thompson Products Inc., 8 pp, ill. Describes a complete line of precision die castings for various industrial uses. (131)

Bearings, Bushings. Wakefield Bearing Corp., 8 pp. Booklet illustrates Graphex, Coprex and Woodex oilless and self lubricating bearings, bushings and machine parts. Also 12-page booklet listing standard sizes of bearings. (132)

Castings and Patterns. Wellman Bronze & Aluminum Co., 16 pp, ill, No. 53. Includes facilities of this company for producing a variety of nonferrous castings and wood or metal patterns. (133)

Screw Machine Products. Westfield Metal Products Co., Inc., 4 pp, ill. Describes facilities for the production of a variety of machined nuts and screw machine products. (134)

Spun Tubing. Wolverine Tube Div., 28 pp, ill. Advantages and numerous applications of this firm's nonferrous Spun End Tube Process. (135)

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, ill. Announces the availability of large-size light alloy forgings, particularly those of magnesium and 75-S aluminum. (136)

Nonmetallic Materials • Parts • Forms

Molded Reinforced Plastics. American Insulator Corp., 8 pp, ill. Gives numerous uses for molded reinforced plastics; includes physical properties. (139)

Acrylic Rubbers. American Monomer Corp., 4 pp. Properties and recommended uses of Acrylin BA-12 and EA-5 acrylic rubbers. (140)

Polyester Resins. Atlas Powder Co., 10 pp. Describes uses, physical properties and general characteristics of Atlas 100% alkyd-type resins. (141)

Gaskets, Packings, Etc. Auburn Mfg. Co., 3 pp, ill. Discusses the various products produced by this company, including gaskets, packings, washers, spacers, seals, shims and bushings. (142)

Balsa Wood. Balsa Ecuador Lumber Corp., ill. Brochure contains a number of sheets discussing various Kilndried Balsa lumber and Balsa products. (143)

Coated Fabrics. The Connecticut Hard Rubber Co. Uses, chemical, electrical and mechanical properties, and availability of heat resistant silicone rubber coated glass fabrics. (144)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Gives dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (145)

Dry Process Molding Materials. Cordo Molding Products Inc. Four bulletins describing Cordopreg dry process methods and their proper use for advantageous results in the reinforced plastics industry. (146)

Plastic. Crane Packing Co., 12 pp, ill, No. T-103. Complete data on Chemlon packings and gaskets fabricated from the new tetrafluorethlyene resin, Teflon. (147)

Industrial Cork Products. Dodge Cork Co. Inc., ill, No. 1h/Do. Includes technical data on cork compositions, natural cork and cork board. (148)

Viscose Rayon for Industrial Use. E. I. du

Pont de Nemours & Co. (Inc.), Rayon Div., 9 pp, ill, No. A-319. Gives physical properties, performance and applications of "Codura", a high tenacity rayon fiber. (149)

Nylon Molded Parts and Gears. John A. English & Co., Nylomatic Div., 1 p, No. 2. Price list of a complete line of nylon molded parts and gears—stock and special stock. (150)

Neoprene Cold Bond System. Gates Engineering Co., 4 pp, ill, No. N-4. Advantages and properties of the Gaco cold bond system for bonding cured neoprene sheet to metal, wood and concrete. (151)

Molded Plastics. General Electric Co., Chemical Dept., 8 pp, ill, No. 1d/Ge. Properties, characteristics and applications of this company's molded thermosetting and thermoplastic parts. (152)

Rubber-to-Metal Adhesive. General Tire & Rubber Co., Chemical Div., 8 pp, ill, No. 4016. Complete data on Kalabond rubber-to-metal adhesive for noncorrosive solvent-resistant bonding. (153)

Plastic-Faced Plywood. Georgia-Pacific Plywood & Lumber Co., 4 pp, ill. Applications, properties and description of GPX high grade exterior plywood coated with plastic. (154)

Molded Plywood. Keller Products, Inc., 12 pp, ill. Booklet describes standard and constantly used die shapes for molding plywood as an aid to designers of molded plywood shapes. (155)

Acid Proof Ceramic Pipe. Maurice A. Knight, 12 pp, ill. Specifications and description of this company's ceramic pipe fittings, said to be almost universally acid proof. (156)

Compression Molded Plastics. Kuhn & Jacobs Molding & Tool Co., 10 pp, ill, No. E-604. Illustrates the facilities of this company for producing compression molded plastics. Includes specifications. (157)

Natural Rubber. Linatex Corp. of America, 4 pp, ill, No. L-101. Features typical applications of Linatex, a special form of natural rubber manufactured in Malaya that is abrasion, corrosion, vibration and chemical resistant. (158)

Electrical Insulation. Louthan Mfg. Co., 13 pp, ill, No. 49-E. Uses and specifications of Louthan insulations in mechanical, electrical, thermal and electronic fields. (159)

Plastics Molding. P. R. Mallory Plastics, Inc., 4 pp, ill. Complete production facilities for large scale production of custom-molded parts from design to finishing and assembly. (160)

Carbon Products. Morganite Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (161)

Glass Fiber Laminate. Narmco Mfg. Co., 4 pp. Gives description and fabricating methods of Conlon Regidglas, a pre-stressed fiber glass laminate that can be formed into shapes associated with plywood or sheet metal fabrication. (162)

Carbon and Graphite Brick. National Carbon Co. Catalog lists principal features of carbon, graphite and some typical metallurgical and chemical applications. (163)

Laminated Plastic. National Vulcanized Fibre Co., 16 pp, ill, No. 1b/12. Physical, electrical, mechanical and chemical properties of Phenolite laminated plastic sheet, rods, tubing and special shapes. Properties of National Vulcanized Fibre also listed. (164)

Molded Nylon. Nylon Molded Products Corp., 4 pp, ill. Presents easy method of calculating the materials cost for a nylon part. (165)

Electrical Insulating Materials. Owens-Corning Fiberglas Corp., 36 pp, ill. Technical data and applications of a complete line of glass-base electrical insulating materials. (166)

Molded Rubber Parts. Parker Rubber Products Div., Parker Appliance Co., 4 pp, ill, No. 5201A1. Lists the many advantages of using Parker custom molded rubber parts in a variety of applications. (167)

Polyester Reinforcing Resins. Pittsburgh Plate Glass Co., 24 pp. Technical data on the Selectron 5000 series of polyester reinforcing resins. (168)

Plastic Glass Laminate. Plastilight Inc., 1 p, ill. Technical data on Epoglass (epoxy resin laminate) for use in electrical and electronic systems such as printed circuits. (169)

Precision Shapes. Precision Shapes Inc., 6 pp, ill. Fabrication process for continuous milling of shapes from solid, rolled, drawn or extruded stock. (170)

Carbon Graphite. Pure Carbon Co., Inc., 32 pp, ill, No. 52. Complete technical data on description, properties, applications and specifications of Purebon carbon graphite. (171)

Extruded and Molded Rubber Parts. Republic Rubber Div., 12 pp, ill. Describes facilities for custom manufacture of molded and extruded rubber products. Describes various products. (172)

Synthetic Flexible Tube Assemblies. Resistoflex Corp., 4 pp, ill. Briefly gives chemical and physical properties obtained with synthetic tubes. Describes types of construction, where to use, and how they solve design problems. (173)

Molded Plastics. Shaw Insulator Co., 6 pp, ill. Facilities for engineering and production of plastic moldings. (174)

Cellular Rubber. The Sponge Rubber Products Co., 20 pp, ill. Properties of, specifications for, and test data on this firm's cellular rubber materials. (175)

Electronic Components. Stackpole Carbon Co., 42 pp, ill, No. RC-8. Catalog shows complete line of this company's electronic components. Includes helpful engineering data. (176)

Ceramics for Electronic Products. Stupakoff Ceramic and Mfg. Co., 4 pp, ill, No. 653. Complete data on Glass 60 metal seals, ceramic-metal assemblies, electronic ceramic materials and printed circuits. (177)

Carbon Brushes, Etc. Superior Carbon Products Inc., 24 pp, ill, No. 6-D. Specifications and applications of a complete line of Superior carbon brushes, carbon and metal graphite plates, silver graphite and silver alloy contacts and brushes, and carbon specialties. (178)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 245 and 246

Vulcanized Fiber and Laminated Plastics. Taylor Fiber Co., 4 pp. Basic properties of plastic laminates and vulcanized fibrous materials arranged in convenient tables. (179)

Plywood. Technical Plywoods. Brief particulars on Plytech, Fybrtech and Carstenite plywoods. (180)

Liquid Polymer Epoxy Resin Combinations. Thiokol Chemical Corp. Folder and technical bulletins Nos. 111, 112 and 113, 1 p each. Technical data sheets on combinations of Thiokol liquid polymers with Bakelite Shell and Ciba Epoxy resins. (181)

Plastics Parts. U. S. Gasket Co., 48 pp, ill. Catalog describes properties and uses of Teflon, this company's various Teflon products, and also gaskets of various materials. (182)

Plastic Rubber Materials. U. S. Rubber Co., 8 pp, ill, No. M-0133. Description, properties, machinability and uses of Enrup plastics, said to fill the gap between rubbers and plastics. (183)

Synthetic Rubber Sheet and Roll Goods. Acadia Div., Western Felt Works, 2 pp, samples. Ten samples clipped to chart of physical specifications. Durometer, tensile and elongation characteristics. (184)

Industrial Plastic. Westinghouse Electric Corp., 36 pp, ill, No. B-3184-D. Properties, grades, shapes, sizes, machining and applications data on Micarta, an industrial plastic. (185)

Finishes • Cleaning and Finishing

Metallizing Processes. Advanced Vacuum Products Inc., 2 pp, Nos. AV55-H and AV-55-L. Technical data on the AV-55-H metallizing process for producing high temperature vacuum-tight seals, and the AV-55-L metallizing process for producing vacuum-tight ceramic seals for low temperatures. (188)

Chromate Conversion Coatings. Allied Research Products Inc., 4 pp, ill, No. 8. Complete data on the basic characteristics of Iridite chromate conversion coatings, and their functions on various metals. (189)

Aluminum Coating. Anodic Inc, 4 pp, with samples. Hard coating for aluminum, its properties and uses. (190)

Rust Preventative. Alrose Chemical Co., 2 pp. Gives preparation and uses of Jetoil No. 1, water soluble oil for blackening ferrous metals by oxidation. (191)

Metal Plating Facilities. American Nickeloid Co. Brochure shows in detail this company's facilities for plating copper, chromium, nickel and brass on various bases for defense purposes. (192)

Corrosion Resistant Finish. American Resinous Chemical Corp., 4 pp, No. C-64. Data sheet describes this firm's corrosion resistant vinyl finishes, their uses, applications, directions and chemical resistance. (193)

Buffs and Polishing Wheels. F. L. & J. C. Codman Co., 24 pp, ill, No. 52. Presents a complete line of conventional and nonfray ventilated buffs and polishing wheels. Includes specifications. (194)

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Metal Washers. Despatch Oven Co., 12 pp, ill, No. 68. Presents complete line of metal washers for metal cleaning and treating applications. (195)

Metal Finishing. Enthone, Inc., 4 pp, No. 13021. Operating instructions for the Ebonal "C" process of blackening and coloring copper and copper alloys. (196)

Industrial Porcelain Enamels. Erie Enameling Co., 15 pp, ill. Lists advantages of porcelain enamels as an industrial finish and shows typical applications where they have been successfully used. (197)

Plating Anodes. Federated Metals Div., American Smelting and Refining Co., 8 pp, ill. Information on copper lead, zinc, tin, tin-lead cadmium, cadmium oxide and brass plating anodes. (198)

Power Driven Brushes. The Fuller Brush Co., 32 pp, ill. Describes Fullergript brushes, their application to such processes as scrubbing steel sheet and tampico brushing. (199)

Disk-Type Buffs. Hanson-Van Winkle-Munning Co., 12 pp, ill, No. B-100. Complete data on Acme Ventilated Ruff-L-Buff pieced and full-disk buffs for cutting and coloring. (200)

Protective Coatings. R. M. Hollingshead Corp., ill. Folder describes Klad Kote corrosion preventives, gives detailed specifications, uses, description and other data in tabular form. (201)

Wax Finishes. S. C. Johnson & Son, Inc., 16 pp, ill, No. ADV 322. Brief description of wax finishes for such materials as rubber, metals, building materials, plastics and paper, and methods of applications. (202)

Metal Cleaning Products. Kelite Products Inc., 6 pp, ill, No. 121. Discusses a complete line of metal cleaning products for use in modern metal finishing. (203)

Corrosion Resistant Coating. Merchants Chemical Co., 4 pp. Gives advantages and outstanding properties of this firm's corrosion resistant coatings. (204)

Aluminum-Chromium Paint. Monroe Co., Inc., 4 pp, ill, No. C-54-8. Includes detailed application data on Monco-alochrom, an aluminum-chromium paint for exterior surfaces of all kinds. (205)

Finishing Equipment. The Murray-Way Corp. Catalog describes full line of this firm's automatic polishing, buffing and grinding equipment. (206)

Aluminum Cleaner. Northwest Chemical Co., 10 pp, ill. Attractively presents information on the Alkalume Process for preparing aluminum for spot welding. (207)

Drum Cleaning. The Pangborn Corp., 6 pp, ill, No. 220. Brochure explains Rotoblast technique in cleaning drums and covers. Also includes safeguards, specifications and diagrams in operation. (208)

Phenolic Resin Coatings. Ric-Wil Plastic Coating & Mfg. Corp., 4 pp, ill, No. S-5252. Characteristics, chemical resistance and applications of Ricwilite 1060, a phenolic resin coating (baked-on) that provides permanent protection for piping and equipment against corrosive conditions. (209)

Aluminum Coating. Royston Laboratories Inc., 2 pp, ill. Discusses Roylac Aluminum, a high quality industrial aluminum coating with the newly developed nonspattering feature. (210)

Paint Spraying Equipment. Scientific Electric, 4 pp, ill. Presents the "Ionic" gun and other ionic high potential paint spraying equipment. (211)

Corrosion Resistant Coating. Specialty Coatings Inc., Div. of Thompson & Co., 6 pp, ill. Examples of how Vinsynite Pretreatment was used in finishing six different types of metal products for good paint adhesion and corrosion resistance. (212)

Zirconium Glazes for Ceramics. The Titanium Alloy Mfg. Div., 30 pp. Description, uses and properties of TAM zirconium glaze opacifiers. (213)

Burnishing. Tumb-L-Matic Inc., No. BB-52. Features, operation and specifications of conventional wooden and molded barrels of high abrasion resistance material. (214)

Heat Treating • Heating

Induction Heating Furnaces. Ajax Electrothermic Corp., 12 pp, ill, No. 13-A. Includes advantages and applications of a complete line of Ajax-Northrup high frequency furnaces for forging, upsetting, spinning, annealing, hardening, etc. (217)

Ovens and Heaters. Burdett Mfg. Co., 11 pp, ill. Covers sheet metal designing and production facilities of this firm—including ovens, heaters, spray booths and washers. (218)

Articulated Hearth. Fahralloy Co., No. 112. Illustrates the Fahralloy articulated hearth of segmental design that permits replacement of any section instead of replacing entire hearth. (219)

Industrial Furnaces. Gas Machinery Co., 4 pp, ill, No. A-100. Describes a complete line of Gasmaco fuel-fired, high temperature furnaces for all types of heat treatment. (220)

Metal Baskets. Hoffman Co., 7 pp, ill. Describes this company's metal baskets, for use in such processes as heat treating, cleaning, dipping and plating. Price list included. (221)

Tube Elements for High Temperature Furnaces. Kanthal Corp., 9 pp. Applications, construction and specifications of Kanthal tube elements for high temperature furnaces used in ceramics, chemical, glass and metal industries. (223)

Inert Gas Generators. C. M. Kemp Mfg. Co., No. 1-10. Technical data on Kemp inert gas generators for heat treating applications and plastics production. (224)

Electric Furnaces. Pereny Equipment Co., 3 pp, ill, No. 4A. Booklet tells advantages and illustrates typical group of this company's furnaces and kilns and their uses. (225)

Sub-Zero Chilling. Sub-Zero Products Co., 12 pp, ill. Complete data on sub-zero chilling for alloy steel heat treatment, metal stabilization, gas dehydration, and parts and material testing. (226)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on pages 245 and 246

Quenching Oils. Sun Oil Co., 8 pp, ill, No. A-2658. Complete data on Sun quenching oils, which can handle 95% of all quenching jobs in industrial heat treating. (227)

Liquid Carburizing Salts. Swift Industrial Chemical Co., 4 pp, ill. Complete data on Swift polytherm blended liquid carburizing salts for imparting a hard, wear resistant surface to steel. (228)

Low Temperature Equipment. Webber Appliance Co., 8 pp, ill. Description of low temperature industrial freezers and complete temperature range testing units. (229)

Heating Units. Edwin L. Wiegand Co., No. 50. Catalog describes this company's industrial heating units, giving specifications and features. (230)

Industrial Furnaces. Lee Wilson Contracting Co., 8 pp, ill. Illustrations of more than 14 furnace types for many large scale industrial uses. Gas, oil and electric heat treating furnaces. (231)

Welding • Joining

Salt Bath Brazing. Ajax Electric Co., Inc., 4 pp, ill, No. 124. Describes salt bath brazing process, gives several case histories indicating economies, and tells how to order units. (234)

Joining and Sealing Aluminum. All-State Welding Alloys Co., Inc., 6 pp, ill. Gives information on how to use and apply All-State alloys and fluxes for soldering, brazing and welding aluminum and aluminum alloys. (235)

Alloy Welding Electrodes. Arcos Corp., 2 pp, No. 44822. Data on 11 alloy electrodes for fabrication welding and salvage of both high and low alloy castings. (237)

Welding Electrode. Champion Rivet Co., 18 pp, ill. Bulletin tells how to choose and use the correct electrodes, and gives information on properties, diameters, polarity, current, etc. (238)

Versatile Adhesives. B. F. Goodrich Co., 8 pp, ill, No. 1-7847-NS. Specifications, compositions, properties and directions for using Plastilock adhesives to bond metal to metal, wood to metal, etc. (239)

Rapid Arc Welding. The Lincoln Electric Co., 48 pp, ill, No. 444. Manual discusses method of arc welding at high speeds and lower costs. Describes procedures for making various types of joints, recommends electrodes. (240)

Silver Brazing Preforms. Lucas-Milhaupt Engineering Co., 10 pp, ill. Features an interesting article on the advantages of using silver alloy preforms. Includes detailed specifications. (241)

Stainless Steel Elctrodes. The McKay Co., 48 pp. Data on arc welding of stainless steels, giving specific uses of alloying elements and specifications of each type of McKay stainless steel electrode. (242)

Soldering and Brazing Equipment. Metallizing Co. of America, 8 pp, ill. Describes Mogul soldering gun and shows applications of its use to production-line soldering and brazing. (243)

Fastener. New Process Screw Co. Bulletin describes Twin-fast screws for rapid fastening of wood to metals, plastics or other woods. (244)

Self-Clinching Fasteners. Penn Engineering and Mfg. Corp., 16 pp, ill. Gives dimen-

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sional data on this firm's self-clinching and self-locating fasteners. (245)

Steel Bolts. Pittsburgh Screw and Bolt Corp., 12 pp, ill, No. 101. Complete data on high tensile steel bolts for structural joints, including a research report and case histories. (246)

Nut Clip Fastener. Prestole Corp., 2 pp, ill, No. 751-A. Engineering and application data of a new heavy-duty nut clip fastener that rapidly assembles heavier gage sheet metal. (247)

Fasteners. Simmons Fastener Corp. Literature describes fasteners especially designed for use in construction where easy demountability is required. (248)

Teflon. Sparta Heat-Treat Co., Plastics Div., 4 pp, ill. Illustrates various Teflon moldings produced by Sparta, and includes a detailed table of typical properties of molded Teflon TF-1. (249)

Self-Locking Nuts. Standard Pressed Steel Co., Flexloc Locknut Div., 27 pp, ill, No. 619-B. Technical data on a complete line of Flexloc self-locking nuts in both thin and regular design. (250)

Stainless Steel Fasteners. Star Stainless Screw Co. Lists Star's stainless and specialty screw machine products available. (251)

Copper-Aluminum Welding. Taylor Winfield Corp., 4 pp, ill. Description of the technique of resistant flash-butt welding for joining copper to aluminum. (252)

Nut Retainers. Tinnerman Products, Inc., 8 pp, ill, No. 245-3. Specifications and descriptions of Speed Grip nut retainers offering a sure method of keeping nuts secure. (253)

Slotted Place Bolts. The Townsend Co., 4 pp, ill. Operational characteristics and torque chart for slotted type place bolts. (254)

Welding Positioners. Worthington Corp., Industrial Div., 36 pp, ill, No. 210C. Description, features and applications of 100 to 40,000-lb. capacity welding positioners. (255)

Forming • Casting • Molding Machining

Zinc Lubricant for Powder Metallurgy. American Cyanamid Co. Technical data sheet describes Cyanamid Zinc Stearate U.S.P. as a lubricant in powder metallurgy. (259)

Metal Spinning. C. A. Dahlin Co., 4 pp, ill. Discusses Dahlin's facilities for metal spinning, saving time, and cutting costs. (260)

Springtites and Sems. Eaton Mfg. Co., 4 pp, ill, folder C-49a. Thread cutting and self tapping springtites and sems. Dimensions. (261)

Die Casting Machines. Lester-Phoenix Inc. Folder gives description, features and specifications of this company's die casting machines and injection molding machines. (262)

Tungsten Carbide Compacting Tools. National Carbide Die Co., 4 pp, ill. Discusses various tungsten carbide compacting tools as they are applied to powdered metallurgy. (263)

Powder Cutting Stainless Steels. National Cylinder Gas Co., 6 pp, ill, No. N-150. Complete data on the NCG Ferrojet process of powder cutting stainless steels. (264)

Presses. Watson-Stillman Co., 8 pp, ill, No. 110-C. Features a variety of metal working, extrusion, hobbing and railroad presses, as well as plastics molding machinery, etc. (265)

Adjustable Perforating Dies. S. B. Whistler & Sons Inc. Catalog describes this company's line of adjustable perforating dies for punching holes in sheet metals. Includes prices and applications. (266)

Inspection • Testing • Control

Laboratory Microscopes. Bausch & Lomb Optical Co., 24 pp, ill, No. D-185. Description and specifications of various microscopes for such uses as metallurgical microanalysis. (269)

Portable Hardness Tester. Blosjo Enterprises, 4 pp, ill. Lists the many advantages of using the Blosjo Porta-Brinell hardness tester. (270)

Fatigue-Testing Machines. Krouse Testing Machine Co., 10 pp, ill, No. 46-B. Describes company's plate and sheet fatigue testing machines, including specifications and testing data. (271)

Automatic Temperature Reading. Illinois Testing Laboratories, Inc., 8 pp, No. 4703. Describes the Alnor Pyrotac, a new temperature control unit that automatically monitors up to 20 individual temperature points a minute. (272)

Temperature Controls. The Pyrometer Instrument Co., No. 150. Catalog shows Pyro Immersion Pyrometer, accurate instrument for nonferrous foundry temperature control. (273)

Radiography. The Radium Chemical Co., Inc., 48 pp, ill. Details of radium radiography, explaining the nature of the equipment and method, recommended techniques and aids to interpreting results. (274)

Tensile Testing Machines. Scott Testers Inc., 6 pp, ill, No. 50. Shows wide assortment of testing machines for testing tensile strength of materials such as rubber, paper, wire and thread. (275)

Temperature Indicators. Tempil Corp., folder, No. 501. Describes temperature indicating crayon, pellets and coating. Shows useful temperature range and uses. (276)

Dye Penetrant Inspection. Turco Products, Inc., 832 E. 62d St., Los Angeles. Bulletin Nos. 101 to 106 explain Dy-Chek techniques; *e. g.*, how to use; surface preparation; applying and removing; applying developer and reading indication. Request on company letterhead direct from Turco.

Impact Tester. U. S. Testing Co., Inc., 2 pp, ill. Includes history, description and use of the SPI low temperature impact tester. (277)

General

Vacuum Unit. Radio Corp. of America, Scientific Instruments Section, 4 pp, ill, No. EM-61. Features, applications, description and specifications of vacuum unit for vacuum deposition of metals and laboratory work. (280)

Materials Controls. Remington Rand Inc., No. KD367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (281)

The Last Word

Some Battery

We had heard many rumors about the wonders of the new nickel-cadmium storage battery, but we find it hard to believe the battery is as wonderful as one published item claimed. It must have been a cold day when the writer wrote and the proofreader read the item. Here is what it said: "(It will) . . . start a car in any kind of weather from 1650 F to –650 F."

More Blades

Just to prove that sometimes the left hand doesn't know what the right hand is doing, last month we ran items in two places describing new uses for old razor blades. We suspected that at least one reader would catch it. Now we are sure, for we have a letter to prove it. The reader also suggests another use—that is cutting out the reader service cards that appear in MATERIALS & METHODS. That's fine with us just so you use them. The same reader comments on our 101 M & M Manuals (now 102) with the word "herrlick!" If our rusty German serves us right, that means magnificent, grand, excellent. With a modest, but proud bow, we say "Thank you".

True or False

We always thought there was another use for blondes other than looking pretty. Now Minneapolis-Honeywell has put blondes to work in the interests of science—at least their blonde hair is put to work. It seems that Swedish blonde hair makes the best reacting element for humidity measuring devices. Naturally the hair must be natural, for the dyed tresses would soon show up as disguised brunette or auburn and therefore unsatisfactory. Among research novelties of the same firm are the use of four white rats who spend all of their working lives chewing on plastics. When the researchers find plastics that the rats don't like, they feel they have overcome one of the long felt handicaps in the use of plastics for household piping and insulation.

She Engineers

The time is ripe, says a female engineer, for women to invade the field of engineering and at the same time help to offset the shortage of engineers which might otherwise plague the country from now on. The lady engineer, Mrs. Lois McDowell, assistant professor of mechanical engineering at Illinois Institute of Technology, points out that 75% of all engineers are in administration, management, design, research and development. Those are areas in which the ladies could most readily fit. The feminine touch might cause many changes in the appearance of engineering departments—for the better, I might add. Perhaps the feminine attitude would be helpful in research, where it is often wise not to take "no" for an answer. Any husband who has had trouble repairing a simple gadget even with his full kit of tools, knows how a woman can solve the problem with nothing more complicated than a bobbypin. We need those talents in engineering.

Dial "S" for Stainless

As one of many who has tried to make a simple story out of the selection of stainless steels, I can attest that it is far from a simple task. However, it has been made to look simple in a new slide selector prepared by Crucible Steel Co. One side of the slide gives you the physical and mechanical properties of any stainless steel including properties at various elevated temperatures. The other side serves as a guide to the best stainless for such attributes as corrosion resistance, resistance to scaling, machinability, weldability and hardenability. All you have to do is set the scale according to instructions and the answers are all there. The commercials are kept to a minimum and the service to a maximum.

T. C. Du Mond
Editor